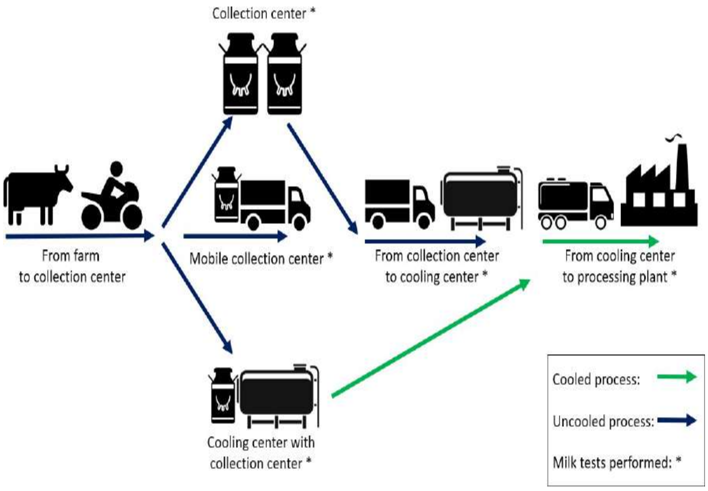
FOOD WASTE REDUCTION AND FOOD QUALITY LIVING LAB – KENYA (FORQLAB)

Food Waste Reduction and Food Quality Living LAB
FORQLAB - Kenya
SIA - CoE Groen – International Food Systems (SDG2) – Kenya - PVG.DZ21.04.001

CHAIN INTERVENTIONS FOR FOOD WASTE REDUCTION AND MILK QUALITY IN THE KENYAN DAIRY VALUE CHAIN

ADVISORY REPORT AND PRACTICE BRIEFS 2022-2024



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This work has been implemented as part of the professorship Climate Smart Dairy Value Chains with students and staff of the Master programmes Agricultural Production Chain Management (APCM) and Innovative Dairy Chain Management (IDCM) at Van Hall Larenstein University of Applied Sciences, the minor Agricultural Development in Emerging Countries at Aeres University of Applied Sciences, and the CoELIB and Animal Science department at Egerton University in Kenya in cooperation with the Netherlands Food Partnership (NFP).

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Foreword

This booklet presents the dairy advisory report and “practice briefs”, which are popular papers based on master and bachelor theses and business assignments of students at two Dutch Universities of Applied Sciences: Van Hall Larenstein (VHL) and Aeres, and Egerton University in Kenya. All theses and business assignments were commissioned through the research project entitled “Food Waste Reduction and Food Quality Living Lab (FORQLAB)” in Kenya.

Background research project

With this project we strived to contribute to structural reduction of post-harvest food losses and food quality improvement in the Kenyan avocado and dairy value chains through the application of technical solutions and tools as well as improved coordination in those food chains.

The consortium had four types of partners: 1. Universities (2 Kenyan, 4 Dutch), 2. Private sector actors in those chains, 3. Organisations supporting those chains, and 4. Network partners. The applied research has been implemented in cooperation with all partners, whereby students at involved universities conducted most of the field studies and all other consortium partners support and interact depending on the phases.

The FORQLAB project targeted two areas in Kenya for both commodities, a relatively well-developed chain in the central highlands and a less-develop chain in Western-Kenya. The research methods were the business to business and multi-stakeholder (living lab) approaches to increase the potential for uptake of successful interventions in the chain.

The project consisted of four phases: 1. Inventory and inception, 2. Applied research, 3. Spreading research outputs through living lab networks, 4. Translation of project output in curricula and trainings. The outcomes were: two knowledge exchange platforms (Living Labs) supported with some advice for sustainable food loss reduction, a research agenda, proposals for ICT and other tech solutions and an implementation strategy; communication and teaching materials for universities and TVETs; and knowledge transfer and uptake.

The project ran from 1 June 2022 till 31 November 2024. Master students have conducted food loss audits, in which they evaluated the current state-of-the-art of food losses in both the dairy and avocado food systems. In the following phase, research agendas were set in multi-stakeholder forums around each participating cooperative followed by in-depth Bachelor and Master research and business assignments from all participating universities.

All research contributions in report and video pitch, you can find on the NFP connect platform: https://www.nfpconnects.com/communities/forqlab-living-lab-on-food-losses-in-kenya

The project team and researchers aimed to contribute to the food loss reduction and food quality in the dairy and avocado sector in Kenya. We hope you will appreciate the efforts reported in this dairy booklet of the project.

Marco Verschuur (project leader FORQLAB) & Robert Baars (prof. Climate Smart Dairy Value Chains)

April 2025

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Towards food loss reduction and improved milk quality in dairy value chains in Kenya

Advisory Report
FORQLAB Project 2025-06

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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van hall larenstein
university of applied sciences

AERES UNIVERSITY OF APPLIED SCIENCES

EGERTON UNIVERSITY

Introduction - Food Waste and Post-Harvest Losses in Dairy

In Kenya, milk is an important commodity at a national level, contributing to 4% of the gross national product (GNP). Informal traders control 70-80% of the milk market (USAID, 2015). Dairy farmers are scattered, leading to extended periods, sometimes up to 3.5 hours, before milk is delivered to collection centres. Challenges like poor milk preservation and mastitis infections cause milk losses. Milk collected in the evening, which comprises 40% of the daily production, is significantly lost due to insufficient on-farm refrigeration facilities. Milk yields are further destroyed when farmers add the evening milk to that collected in the morning. Other loss variables at the trading and transportation stage include poor milk storage, bad roads and adulteration.
Milk losses are significantly attributed to cooperatives and milk collection centres, i.e., 74%, while the informal sector, e.g., milk bars and traders/transporters, contributed 26% in losses of the total milk produced and marketed (Omondi et al., 2017). Therefore, interventions such as hygiene at milking, storage (e.g., stainless steel milk cans), cooling, milking and collection routines (e.g., twice-a-day) significantly improve quality and reduce losses.

Improvements in milk handling are most successful in formal chains. The proportion of milk entering the formal channels is approximately 30% (Nyokabi et al., 2021), but has been increasing due to growing demand for safe milk (Alonso et al., 2018; Bebe et al., 2018). However, in some cases, milk is re-contaminated after pasteurisation due to unhygienic handling practices (Lindahl et al., 2018). Women play an important role in dairy farming—especially milking and feeding—and are also involved in collecting, processing, and marketing dairy products (FAO, 2021). Research and development investments in the dairy sector can contribute not only to livelihood security but also to gender equity and nutritional improvements for women and children.

Challenges in the Dairy Value Chain (DVC)

Dairy processors experience difficulties and bear the risks of handling a highly perishable commodity like milk, especially from smallholder farmers, leading to large price fluctuations, increased spoilage and economic losses. Milk losses in Western Kenya have been quantified at about 2% at the farm and 84% at the collection and processing level (Omondi et al., 2017). Food waste reduction in DVC requires interventions at the farm/collection and processing levels. The Kenyan formal dairy chain faces the following challenges:

i) Substantial post-harvest milk losses at the farm or collection level. 6% of the total milk produced (~60 million Kg) is lost at the farm level (FAO, 2011);
ii) Poor rural infrastructure, lack of reliable refrigeration, inefficient and inadequate transportation of raw milk and poor access to dairy markets (Omondi et al., 2017);
iii) A large number of small-scale processors (USAID, 2015);
iv) Fluctuations in milk supply due to seasonal forage availability;
v) High consumption of unprocessed milk (only 20-30% is processed). About 55% of the milk enters the market, the rest is consumed at home (USAID, 2015);
vi) Inadequately trained and qualified staff at all levels of DVC (Rademaker et al., 2016); and
vii) Few well-organised DVCs (Wanjala et al., 2015).

Chain Governance
Bebe et al. (2018) considered the 3R-indicator model as a sustainable approach for chain governance, i.e., robustness of chains, reliability of institutional governance, and resilience of the innovation support system. Good governance activates chain cooperation and quality control measures. Building truly inclusive value chains requires close cooperation and continued exchange of knowledge and evidence between research, policy and practice (F&BKP, 2015).
From a business perspective, chain challenges can be structured as:

- Technical (e.g., processing, cooling, sensors, containers and poor roads).
- Procedures and systems (e.g., ordering procedures, quality assurance frameworks, logistics and planning).
- Relations between actors (i.e., types of contracts, service level agreements and information sharing).
- Support services (e.g., technical assistance, agro-inputs, finance and information and communication technology [ICT])
- Competences of management and workers (i.e., capacity to adapt new-tech solutions, collaborate or evaluate product quality).

Opportunities for ICT and Technology
Different options for tech-based interventions within the DVC are possible, including:

1. ICT and digitalisation solutions
2. Processing (post-harvest) related solutions to improve quality, prolong shelf life or creating new products for other channels (food and non-food).
3. Production solutions, e.g., during monitoring, crop protection and harvesting.

Research Questions formulated during the project
This project was implemented from 2022 to 2024, funded by SIA (part of Dutch Research Council NWO) and had the following research questions:

1. What is the governance of the dairy value chain?
   a. What is the organisation of the dairy value chain (logistics, buying, marketing)?
   b. What kind of chain (business to business) relationships (contracts, information sharing, financial) are present?
   c. What are the actual milk losses at production, processing and distribution levels?

2. What technical interventions are required to encourage safe products and reduce food losses in the dairy food systems?
   a. What are the actual milk losses at production, processing and marketing levels?
   b. What sustainable technical innovations can be implemented to reduce losses?
   c. What are the trade-offs of proposed interventions?

d. What is the feasibility of ICT applications in providing transparency, traceability, increased food safety and linkages to markets?

3. What governance interventions are required to encourage safe products and reduce food losses in the dairy food system?
    a. What is the effect of good practices on the business models of entrepreneurs?
    b. What are successful scaling mechanisms for proven quality assurance and food loss reduction practices?
    c. What are effective ways to improve organisational linkages considering the capacities of different private and public stakeholders?
    d. What policies impact on performance of food safety and rural entrepreneurship?
    e. What is the role of cooling, processing, packaging, quality control and certification on consumer confidence in Kenya?

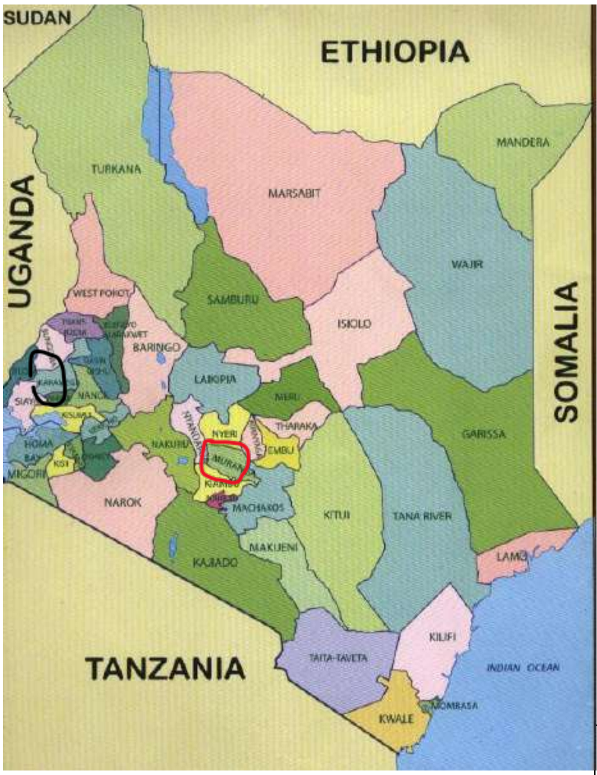

Figure 1: Study Areas in County map of Kenya

Legend:
Bungoma – black
Kiambu - red

Study Area

Two dairy value chains were purposely selected as case studies. Githunguri Dairy Farmers' Cooperative Society (DFCS) in Kiambu County is a relatively well-developed whereas Kitinda and Kaptama DFCSs in Bungoma County are relatively less developed (Figure 1).

Research Design

The project implemented a multi-method research approach. It started with two food loss audits in the study areas to identify the hotspots in the dairy value chains, followed by eight in-depth studies, which were based on a research agenda set by the project team and the cooperatives in multi-stakeholder meetings and about seven business assignments, implemented in student groups. The research topics are grouped around three themes (Table 1):

Table 1: Study research topics

Area	Topics
A. Milk losses	• Food loss audits • Introduction of bucket milk machines • Transport of milk • New dairy farm model
B. Chain Governance	• Cooperative development • ICT solutions • Linking to finance
C. Milk quality	• Milk handling • Feed quality • Contaminations in milk • Readiness for a quality-based milk payment system (QBMPS)

Data Analysis
Students used the following resources:

- Value chain analysis tools (GIZ, 2017) to map the value chains (Figures 2 and 3)
- The 3R-framework (Bebe et al., 2017) to describe the chain governance
- FAO (FAO, 2019) and KALRO (Omondi et al., 2017) models to calculate food losses
- Business model canvas by Osterwalder and Pigneur (2009) for business modelling

Dairy value chain maps and food loss hotspots
In the Githunguri and Kaptama research areas, students identified the value chain stakeholders as well as the food losses and hotspots (Katarama, 2022; Kemboi, 2022) and mapped them (Figures 2 and 3).

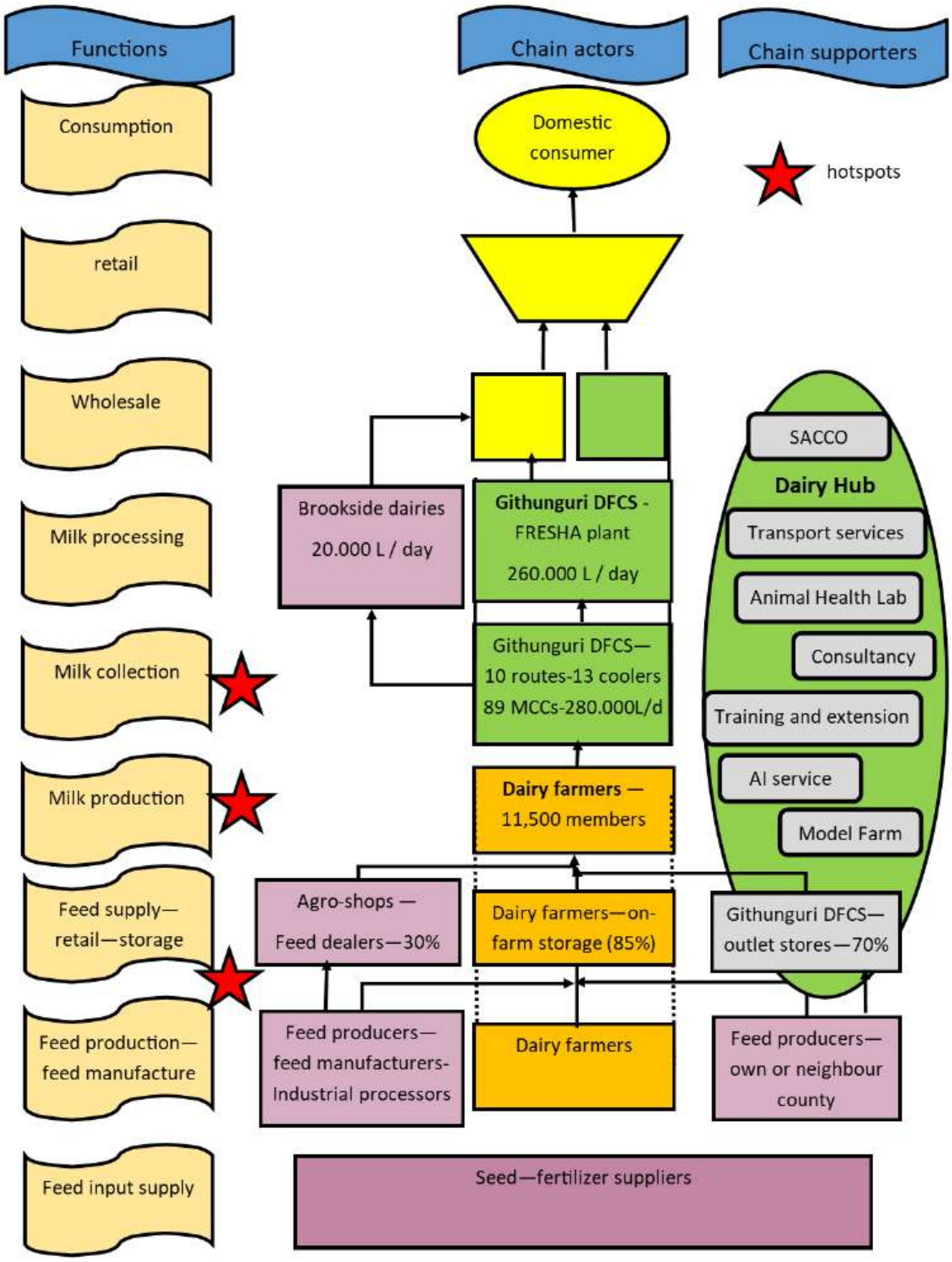

Figure 2: Githunguri DFCS dairy value chain (anno 2024) map with food loss hotspots
Source: adapted from (Katarama, 2022; Guled, 2023; Verschuur et al., 2020).

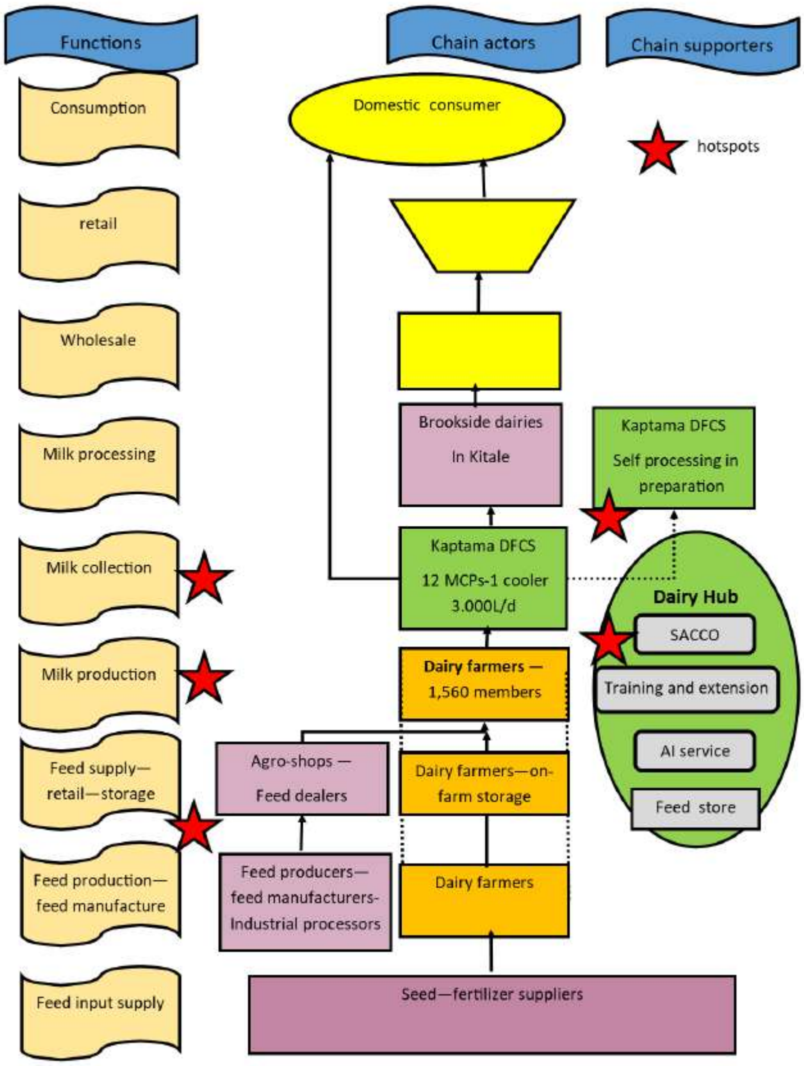

Figure 3: Kaptama DFCS dairy value chain (anno 2024) map with food loss hotspots
Source: adapted from (Kemboi, 2022; Verschuur et al., 2020).

In contrary to pre-studies indicated (Omondi et al., 2017), hotspots at Githunguri DFCS were primarily on the farm level (94%) and downstream. Although the post-harvest losses were quite low at the processing level, Githunguri DFCS was still unsatisfied with the milk quality collected from their members (farmers). For Kaptama DFCS, the main hotspots were at the collection level (73%) (Table 2), while for Kitinda DFCS, the main hotspot was at the cooperative level due to financial constraints and limited daily milk intake of only 400 L/day.

Table 2: Post-harvest milk losses of Githunguri and Kaptama DFCS. Sources: Katarama, 2022; Kemboi, 2022.

	Githunguri	**Kaptama**
Total milk intake / day	280.000 L	3.000 L
Total Loss / year	2.522 M liters	104 k liters
Economic value	113.5 M KES	4.7 M KES
Food loss share: Farm level (spoilage-spillage)	94%	22%
Collection level (spoilage)	5-6%	73%
Processing level (spillage)	<1%	5%
Seasonality – main losses	Wet season (56%)	
Adulterated milk	Rejected – locally sold	Rejected - Locally sold

Losses due to milk adulteration were losses to the cooperative rather than to the food system, because rejected milk is fed to animals or sold. Anyhow, selling rejected milk is still a risk for vulnerable consumers, since it can cause health problems. Losses due to mastitis and spillage are disposed of.

Impact pathways for food loss reduction in the dairy value chain

I. *Technical action perspectives (based on the milk loss audits)*

At **the input supply level**, dairy feeds are an important carrier of aflatoxin and pesticides contaminants, which could cause milk rejections. Action perspectives include:

- *Testing feed quality* on contaminants and good storage at the (agro-vet) store.
- *Routine feed quality assessments*, where farmers and feed formulators perform periodic chemical analyses to monitor feed quality, given the significant variation observed due to species, maturity stage, and management practices.
- *Improving feed processing and storage* through efficient postharvest handling and drying methods to reduce fungal growth and aflatoxin production in animal feed, as well as regular monitoring and quality control along the feed supply chain.

At the farm level, milk losses occur due to spoilage and spillage. Important measures are milking hygiene, testing of clinical mastitis, cleaning and drying milk buckets (not jerrycans) and milking utensils, as well as cooling the milk directly after milking and avoiding adulteration. Avoiding cow mastitis remains an important measure at the farmer level (FORQLAB 2022-01; FORQLAB 2022-09). Less visible are aflatoxin, antibiotics, acaricides and pesticides contaminants, which all occur due to husbandry, feeding and milking practices (FORQLAB 2024-01). A substantial proportion of animal feed and raw milk samples (in Kitinda and Kaptama DFCS) contained aflatoxins above recommended safety limits**.** Moreover, a strong positive correlation was found between aflatoxin levels in feed and milk (FORQLAB 2024-07). Nevertheless, contaminated milk (and colostrum) was consumed by animals (calves, pigs and pets). Action perspectives include:

A. *Awareness raising for farmers about the causes and effects of milk losses. Training topics include (FORQLAB 2022-01; 2022-03; 2022-09; 2022-10; 2023-11; 2024-01; 2024-07):*
    - *Feeds, feeding and aflatoxin prevention:* Good preservation of animal feeds, especially maize meal and bran, by drying or reducing the moisture content of animal feed (grasses and forages) without losing nutritive value.
    - Mastitis prevention measures, including reducing antibiotic use.
    - Disease treatment and observation of withdrawal period: Proper dosage and avoiding self-treatment at the farm level without consulting extensionists or veterinary service providers.
    - Measures to reduce the incidence of acaricides: Spraying/dipping 8 hours before milking, udder cleaning, spraying at a distance from the milking area, and accurate dosing.
    - *Milking*: Maintain hygiene during milking, clean the udder to reduce acaricides, cool immediately after milking, properly store milk, and separate morning and evening milk.
    - Milk quality assurance (Hazard Analysis and Critical Control Points - HACCP) and good manufacturing practices (GMP).

B. *Feeds, feeding and feed control (FORQLAB 2024-07)*
    - *Utilisation of crop residues:* While crop residues such as maize stover and sugarcane tops have limited nutritive value, their abundance makes them viable basal feeds.

However, they should be treated (e.g., urea treatment) or supplemented with protein-rich forages to improve their usability.

- *Promotion of fodder legumes:* Encourage the integration of high-protein fodder legumes (e.g., lucerne, desmodium and leucena) into feeding systems to increase protein supply, improve fermentation and support animal productivity.
- *Feed conservation strategies:* Due to the high quality of some seasonal forages (e.g., super napier and lucerne), proper hay or silage-making conservation should be promoted to ensure year-round availability.
- *Farmer training and capacity building:* Training farmers on optimal cattle feeding practices, reduction of aflatoxins, proper feed handling and storage techniques, including nutrient-rich diets and breed selection, to enhance milk quality.

C. Technological Investments (FORQLAB 2022-01; 2022-02).

Establishing simple and affordable bucket milking machines, solar panels, and milk test kits at the farm level need more investment (money and time). The following observations were gathered from farmers regarding bucket milking machines: (1) They help ease load of work; (2) They decrease worker turnover; (3) They reduce prevalence of mastitis within the herd; (4) They produce clean milk free of contaminants; (5) They allow workers to attend to other duties while milking (FORQLAB 2022-02).

- Interventions to promote access to milking machines should focus on (1) promoting the uptake of milking machines; (2) Training and extension; (3) Developing a business model for sales agents; (4) Setting up demo farms; and (5) Promoting access to credit (FORQLAB 2022-02).

D. Extending the shelf-life

- Establishing milk preservation or cooling methods at the farm level: Focusing more on spreading the technology of soaking milk buckets in clean and cold water and observing general milk hygiene.
- Fermentation of evening milk to add value and extend milk shelf life.

E. Further research

Also, further research is needed at the national level to determine the extent of antibiotic residue and aflatoxin levels in the milk to make a better decision in reducing the cases of antibiotic residue and aflatoxin in milk.

At the **milk collection level**, milk loss is widely attributed to adulteration and wait time between milking and cooling, since milk deteriorates quickly. Farmers and collectors must avoid contamination (with water or cleaning residues), and adulteration, as well as avoid mixing the evening milk with the morning milk– especially in remote areas without cooling options, while reducing the transport time from the farm to the (mobile) collection point and thereafter to the cooling centre. Moreover, jerrycans must be avoided, since they are difficult to clean compared to stainless steel buckets. The cooling equipment must function well (electricity security), and simple milk tests (smell, density/lactometer, alcohol) must be implemented *(FORQLAB 2022-01; 2022-02).*

At the end of the project, Kaptama DFCS reported that the introduction of stainless-steel milk buckets increased milk intake considerably, as there were fewer rejections. Action perspectives include (FORQLAB 2022-01; 2022-03; 2022-09; 2022-10; 2023-11):

- *Awareness raising at collectors' level:* Increasing the training frequency from once to twice per month to increase the graders', inspectors', and extensionists' awareness of current situations at the farm, including training on milk handling during testing, measurement, and storage.

- *Motivating farmers based on the quality of milk produced* quarterly (every 3 months) by providing certificates of appreciation/recognition or other incentives.
- *More attention should be paid to an evening or a three-interval milk collection shift:* The evening shift should be considered the main collection period to reduce spoilage and rejection from mixing the evening and morning milk.
- *Installing solar power:* Solar power at cooling points may reduce running costs (e.g., electricity bills) and possible losses due to a power outage. Although further research indicated the low power of solar panels to cool the milk in a short time.

At the processing level, bulk testing for contaminants is essential but very costly. Action perspectives include (FORQLAB 2022-01; 2022-03; 2022-09; 2022-10; 2023-11):

- *Awareness raising* at processing level, about appropriate preservation, processing technologies and milk hygiene during testing, measurement, packaging, and storage to avoid milk contamination and spillages.

At **the retail level**, milk bars or ATMs in small shops or supermarkets are a new phenomenon. The biggest reason for milk waste is poor or no cleaning of the ATM.

II. Governance Impact Pathways

A. Improve governance along the chain and at the cooperative level

Effective cooperative governance enhances the reduction of food losses and improvement of food quality. A competitive cooperative society, with a stable or growing member base, can strengthen quality and reduce food loss through internal policies or physical investments.

During the project, Kitinda DFCS created policies to clear its electricity debt and revive the cooperative. Student assignments helped them discuss options with the local government. Kaptama DFCS increased its membership by almost 400% (now at 1,560 members) and increased the daily milk intake by 500% (from 600 kg to 3,000 kg/day). They linked farmers to related business services (e.g., finance, artificial insemination, feeds and input, etc.) and made B2B linkages for milking, cooling and milk processing equipment (Ante).

Kaptama DFCS was also able to reduce milk spoilage and spillage through training famers in cow handling and hygienic milking procedures and to use metallic milk cans (increase of 200 kg milk/day through less milk rejections), train milk transporters to use metallic cans which reduced spillage (from 40 kg to 5 kg/day), train farmers in feed and forage management to reduce aflatoxins. They were more secure in the testing policy (organoleptic, lactometer and alcohol tests) at collection point and cooling centre. They could secure the electricity provision of the cooling centre (M. Ngeywo, pers. comm.).

Githunguri DFCS created policies and regulations to shorten cooling time. The cooperative adopted a twice-a-day intake policy and opened two more collection points and a cooling centre. Milk collection points should be no more than 2 kilometres from a farm. Alternatively, farmers should have home cooling options. To improve the milk quality, stainless-steel buckets should be used, milk testing should be done, and cooled tanks should be used to transport milk. Githunguri DFCS considerably reduced milk rejections by 90% and 50%, respectively, by increasing milk clotting/mastitis and antibiotics testing. They also bulk test for aflatoxins and somatic cell count (SCC). They also discussed the cooperative's support in investing in milk bucket machines and the readiness to start a quality-based milk payments system (QBMPS). This also increases the farmers' and cooperatives' awareness and motivation for producing safe milk. Furthermore, they invested in extension services (through a Tetra Pak project) and group learning trajectories, e.g., (group) training and model farms. (F. Muhande, pers. comm). Further action perspectives include:

B. *Infrastructure development, rural roads, and electricity connectivity to mitigate loss.*

C. *Cooperative development (FORQLAB 2024-10; 2024-11; 2022-01; 2022-03)*

- Strengthening the capacity of the cooperative management:
  - Reviewing and revising the cooperative's bylaws and policies to ensure they are aligned with best practices.
  - Developing and implementing communication strategies to improve member engagement and participation.
  - Providing access to affordable credit for members through partnership with savings and credit cooperative organisations (SACCOs).
  - Establishing an internal monitoring and evaluation system to track progress against goals and adjust as necessary.
  - Establishing a payment system for farmers where they get paid weekly for the milk delivered.
  - Organising exchange visits to Githunguri DFCS.

- Improving market linkages
  - Conducting market research to explore potential buyers and market trends (for self-processed dairy products).
  - Developing and implementing a marketing plan to target potential buyers and increase sales.
  - Rebranding of products and cooperative reputation.

- Improving milk collection networks
  - Implementing fixed milk collection schedules (morning + evening milk)
  - Using milk applications (digital information systems)

- Enhancing milk quality and minimising milk wastage within the co-operative
  - Using stainless-steel milk cans as opposed to jerrycans
  - Providing adequate testing equipment to assess milk quality and identify areas for improvement.
  - Rewarding milk quantity instead of milk quantity (volume).
  - Providing incentives at the end of every six months to the farmer who supplies the milk that meets the cooperative milk standards.
  - Recognising farmers with low or non-incidence of mastitis cases.

- Enhancing milk handling and quality control systems:
  - Introducing affordable milk testing kits, hygiene training, and cooling/storage technologies at household and collection levels to reduce spoilage and improve quality.
  - Establishing stronger linkages with milk processors and buyers that offer premiums for quality.

- Training farmers
  - Awareness raising on different topics concerning milk quality.

- Developing or improving milk processing units
  - Develop market channels and arrange the necessary certifications.

D. *Establishing a QBMPS (FORQLAB 2023-11)*

- Creating awareness among the dairy stakeholders on the general overview of post-harvest losses, field visits and media campaigns across Githunguri DFCS platforms and the national website.
- Encouraging the main drivers of the cooperative to adopt QBMPS, i.e., milk quality, fair compensation for farmers, market competitiveness through the offer of premium products, sustainability and member engagement.
- Diversifying products and entering new markets through QBMPS.
- Enhancing farmers' understanding and their participation for improved milk quality and economic benefits.
- Enhancing cold chain infrastructure and sustainability practices, underlining the need for continuous improvements in various aspects for successful QBMPS integration.
- Piloting a QBMPS implementation study for 50 selected mid- to large-scale farmers, based on earlier studies in Uganda (Daburon and Ndambi, 2019).

E. ICT and digital financial solutions

Due to the low daily intake, Kitinda DFCS didn't use any digital system. Such a tech solution was not affordable. Kaptama DFCS used a digital system for farmer registration and data collection and used M-Pesa (a nationwide mobile money system for C2C or B2B payments) or cash to pay the farmers. In Bungoma County, only 31% of the farmers used digital financial services (payment, credit, savings, remittance, insurance, etc.) (FORQLAB 2024-08).

Githunguri DFCS used a Product Information Management (PIM) app for data collection and communication. The data collection and payments are fully automated (FORQLAB 2022-10).

Other action perspectives include:

- Installing milk apps (e.g., KALRO: see https://www.kalro.org/navcdp/index.php/information-resoures/mobile-apps) for the short term will improve information flow between the cooperative and farmers.
- Investing in management information/data analysis systems for the long term. Cooperatives have been linked to supply chain management systems, such as eProd Solutions Ltd.
- Introducing digital financial services (DFS) (FORQLAB 2024-08):
  - Targeted education campaigns will be introduced, highlighting the benefits of DFS.
  - Improving access to tailored credit facilities that meet the specific needs of smallholder dairy farmers.
  - Establishing inclusive community-based support networks that promote gender equity and peer learning.
  - Building trust and formalising markets and market structures by partnering with trusted local institutions (e.g., cooperatives, SACCOs, agrovets), including use of e-receipts, contracts, and traceable transactions.
  - Integrating DFS into extension services and training to include DFS modules in farmer field schools, cooperative training, and dairy sector forums.

F. New farm and extension models

Githunguri DFCS realised that urbanisation is growing and that dairy farm sizes in Githunguri Subcounty will be too small to make a reasonable living in the long term. Therefore, they developed a new farm and extension model with partners through group learning trajectories and model farms (aided by a Tetra Pak project). FORQLAB students contributed to designing future farms and future chains (Figure 4). Main characteristics of future farms, based on Baars & Verschuur (2020):

- Climate-smart or organic production standards
- Large farm size and larger herd size, but lower cows per hectare
- More roughage production from the own farm (fewer inputs)
- Improved manure utilisation, lower Nitrogen emissions
- Agroforestry and intercropping
- Adopting technological innovations, such as bucket milking machines, biogas installations, and solar panels to reduce electricity costs and/or milk waste.

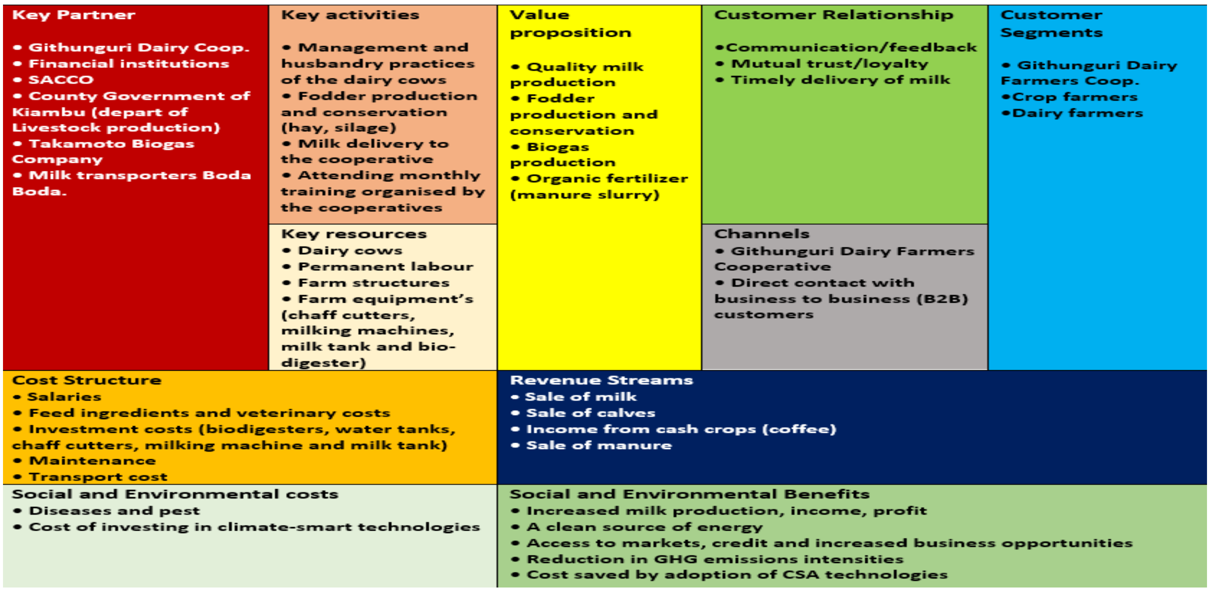

Figure 1: Sample Business Model Canvas for a Githunguri future farm. Source: E. Effiong & I. Guled, 2023 (APCM assignment)

G. *Creating partnerships and coalitions (FORQLAB 2024-01) and developing information networks (FORQLAB 2022-01).*
   - Partnering with other cooperative societies by onboarding the cooperatives as new milk suppliers. These cooperatives were already established and produced high volumes of milk.
   - Collaborating with private companies in Kenya, especially those in the food and feed industry, working with international standards, and linking farmers to these companies would allow farmers to access quality products with low contaminant levels. When farmers use these products, their milk conforms to the required standards and can be onboard with Bio Foods.
   - Policy and Regulatory Support:
     - Supporting farmer cooperatives to standardise milk quality and improve access to safer, processed feed.
     - Supporting farmers through training and implementing practices that ensure that milk meets the required standards. Collaboration between cooperatives and the Kenya Dairy Board (KDB) will be essential for improving milk quality.
   - Informing dairy sector players of the impacts of post-harvest losses for sound decision-making.

H. *Curriculum Development for TVETs (FORQLAB 2024-04)*

The curriculum development team, existing of 6 lecturers of 5 different TVETs and Egerton University, designed two module descriptions for the dairy sector: Dairy Quality Control Officer and Extension Officer. These modules will be implemented in current modules of the TVETs involved.

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Post-Harvest Loss Reduction in Milk Value Chain.
A case study of Githunguri Dairy Farmers Cooperative Society in Kiambu County, Kenya

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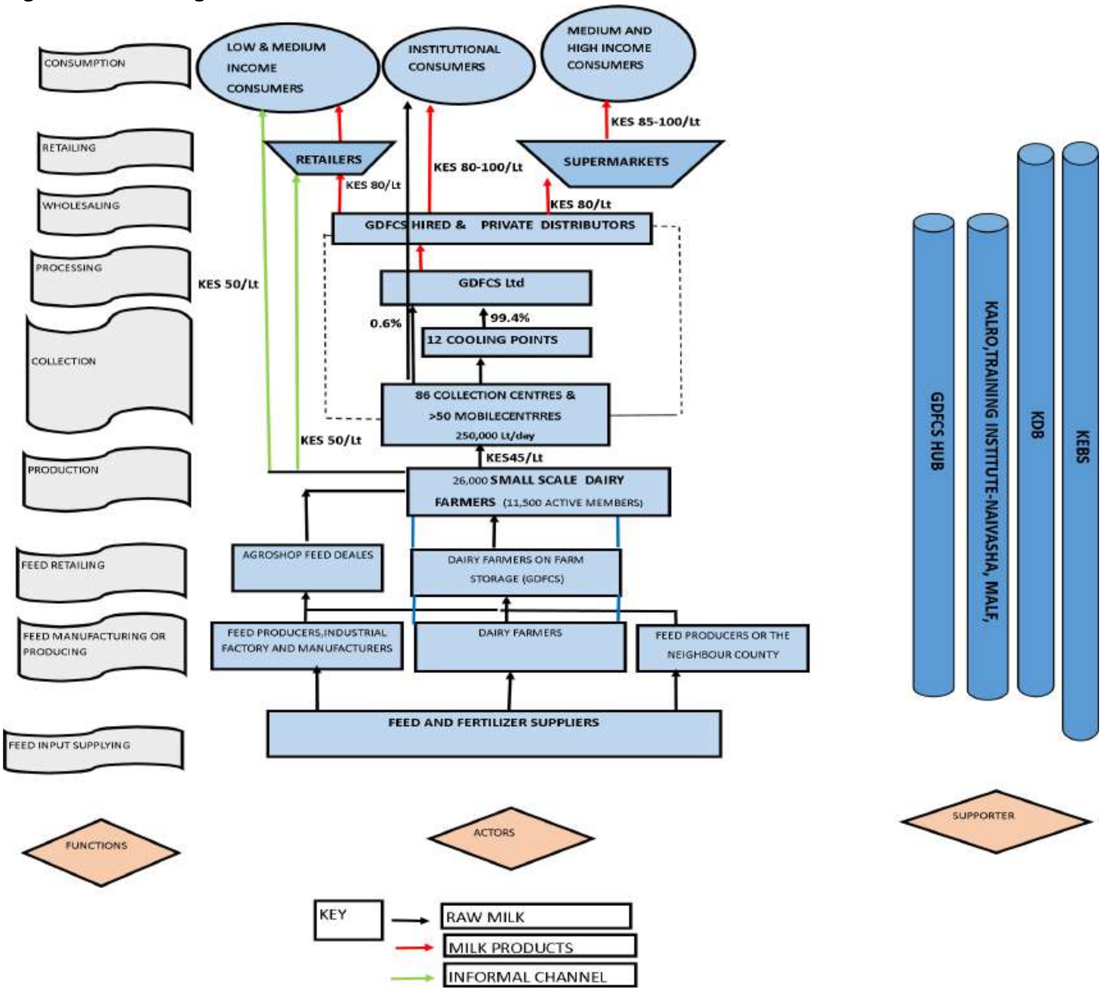
Practice Brief
FORQLAB Project 2022-01

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

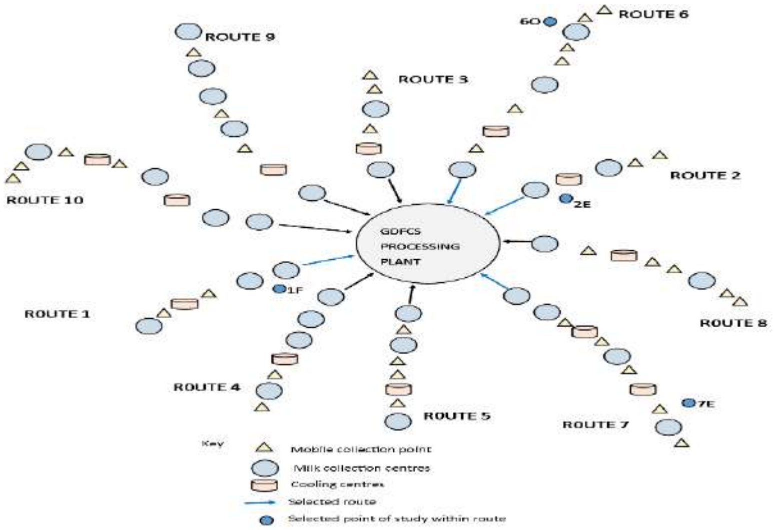
Despite efforts of several researchers in Kenya, post-harvest loss (PHL) in the milk value chain is a persistent challenge in the dairy sector. This study was conducted to investigate PHL reduction in the milk value chain using Githunguri Dairy Farmers Cooperative Society (GDFCS), Kiambu county – Kenya, as a case study. GDFCS was chosen based on their efforts toward the reduction of PHL, such as having the best governance system and efficient milk collection system (Figure 1).

Figure 1: Githunguri milk value chain



The objective was to give an overview of PHL and develop sustainable interventions for PHL reduction at production, collection, and processing level of the milk value chain. Milk is a perishable commodity and thus requires good handling to ensure its safety and quality at different levels of milk value chain. Both FORQLAB and GDFCS were lacking an overview of PHL, such as the volume of rejected milk, causes of loss, economic and carbon footprint impacts, rejected milk chain and possible interventions to mitigate the losses.

Figure 2: Milk collection routes



Methodology

The methods for data collection were interviews with 18 key informants in the value chain, 2 focus group discussions and a survey among 40 farmers registered under the cooperative of which half were belonging to the short collection routes and the other half to the long collection routes (Figure 2). The information collected from the survey was statistical analysed to compare means and partly to test significance by using the Independent Sample T-test (in SPSS version 26). The descriptive statistics were run on frequency, means, and comparison of means into different groups. Food losses were calculated through extrapolation of the survey data to cooperative level (% of loss per milk produced x cooperative intake). The interview information was coded and transcribed. The secondary data were collected by reviewing the existing literature and compared with the finding under this study. The research team comprised the VHL student, VHL supervisor, extensionist and the cooperative staff.

Farmers' production parameters

It was revealed that Friesian is the most kept dairy cattle breed as reported by 95% of the respondents, and farmland size owned per farmer was 2.48 acres. Farmers in Githunguri were aged between 36-60 years. Farmers depended on livestock keeping as a source of income as mentioned by 90% of the respondents. Furthermore, there was little difference in production data between farmers of the short or long route (Table 1).

Table 1: Key production parameters per short and long route of Githunguri DFCS

Parameter	**Short route N=20**	**Long route N=20**	**Total N=40**
Dairy as main income [%]	90%	90%	90%
Land size [acres]	2.65 ± 0.5	2.30 ± 0.5	2.48 ± 0.6
Herd size [heads]	4.45 ± 1.9	2.0 ± 0.9	3.2 ± 1.9
Milking cows [heads]	2.55 ± 1.0	1.87 ± 0.6	2.21 ± 1.0
Calving interval [months]	12.8 ± 0.6	13.50 ± 1.6	13.14 ± 1.3
Milk yield / cow / day [liters]	10.0 ± 1.5	10.4 ± 2.1	10.2 ± 1.8
Lactation length [days]	327	324	324
Milk yield / cow / year [liters]	3570 ± 1164	3350 ± 1250	3460 ± 1197
Milk yield / farm / year [liters]	6030	6210	6120
Peak production dry season [lt/cow/day]	12.4 ± 4.4	9.8 ± 3.0	11.1 ± 4.0
Peak production wet season [lt/cow/day]	18.9 ± 5.8	16.1 ± 4.5	17.5 ± 5.3
Distance from farm to collection [min]	9.9 ± 4.9	11.2 ± 5.6	10.5 ± 5.2

Food loss

Although GDFCS is a well-developed cooperative, they are still experiencing quality problems in the milk collected. The cooperative has made efforts in reducing losses by reducing the distance from farm to collection centres and introducing the cooling point in the milk collection route to maintain the quality of milk. The cooperative has good information between farmers and staff. Although, the there is a need to develop an information network between cooperative and other stakeholders.

The survey respondents were not aware of the volume of milk lost yearly and the economic impact incurred annually, although they were aware of the causes and influence of season on milk loss. The estimated volume of PHL in the Githunguri milkshed was 2,521,981.6 Lt/year (2.8%) which was equivalent to KES 113,489,172. The PHL share in the milk value chain was highest at the production level (94.39%) compared to collection (5.39%) and processing level (0.22%) (Figure 4). The estimated carbon footprint was 183,946,743 kg CO_2 eq FPCM at the GDFCS milkshed thus contributing 1.5% nationally.

Figure 3: Calculated food waste per food loss level

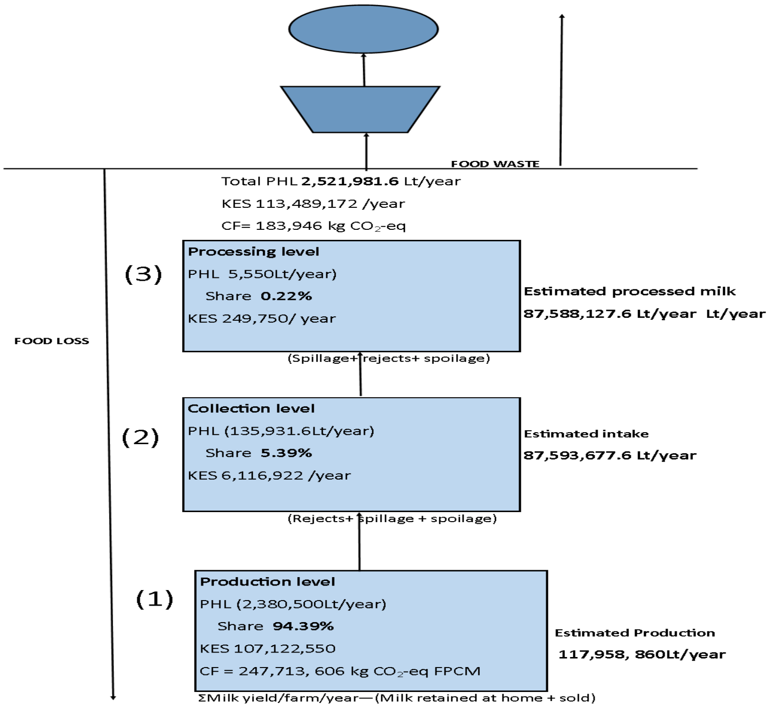
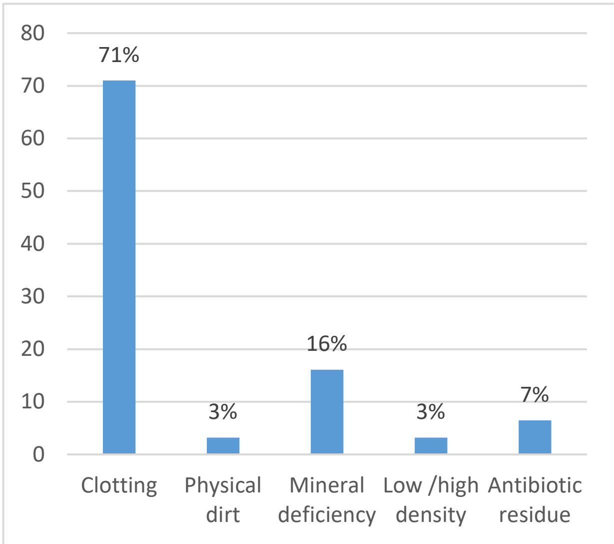


Figure 4: Causes of milk spoilage



It was revealed that 3.6% of the volume of milk produced annually was lost through spoilage, spillage and rejection. The amount of PHL between the long and short routes was not influenced by the distance (Table 2). Table 1 shows that there was no difference in time taken from the farm to the collection centre between the short and long routes, on average 10.5 minutes.

The high amount of PHL at the farm level was due to milk rejection caused by mastitis (clotting), a high amount of antibiotic residue in milk, and low/high density of the milk. The milk spoilage was caused by contamination with physical dirt due to poor milk hygiene (Figure 4). At the collection centre, the PHL was highly influenced by the missing milk due to rejection and error during milk measurement. At the processing level, the PHL was highly caused by spillage in packaging areas.

Table 2: Milk losses in Githunguri DFCS per month comparing short and long routes

Parameter	**Short route N=17**	**Long route N=17**	**Total N=34**	**p-value**
Intake (lts/month)	86532 ± 42971	131349 ± 53073	108940 ± 52710	0.011
Rejects (lts/month)	108 ± 100	184 ± 266	150 ± 207	0.462
Missing milk (lts/month)	50 ± 56	91 ± 110	70 ± 89	0.18
Spoilage (lts/month)	36 ± 6	43 ± 6	40 ± 7	0.282
Total Loss (lts/month)	73 ± 98	207 ± 241	193 ± 232	0.11
Total Loss (lts/year)	38276 ± 33770	75461 ± 87821	56868 ± 68180	0.11

The wet season had a great share to PHL due to mastitis incidences and physical dirt resulting from poor milk hygiene in dirty cow sheds (Figure 5). The disposal channels of rejected and spoiled milk were feeding to animals (calves, pig and dogs), selling and home consumption and the milk with clinical mastitis were poured on the ground though other farmers were feeding to pigs and dog (Figure 6).

Figure 5: Influence of seasonality in milk rejection

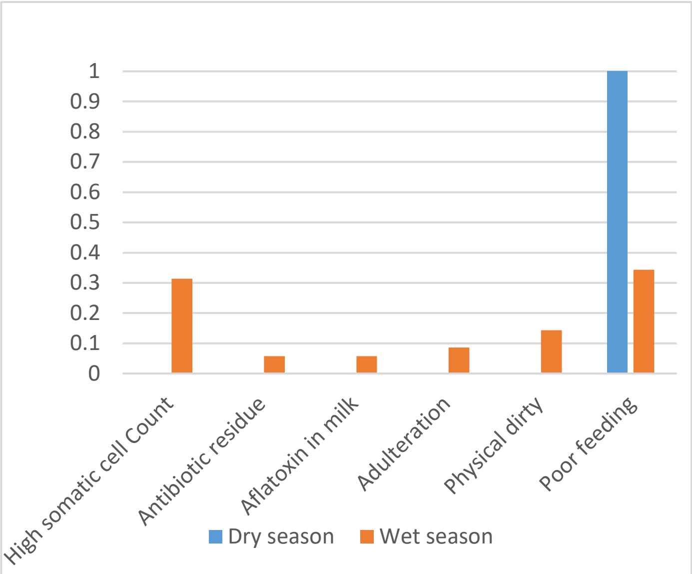
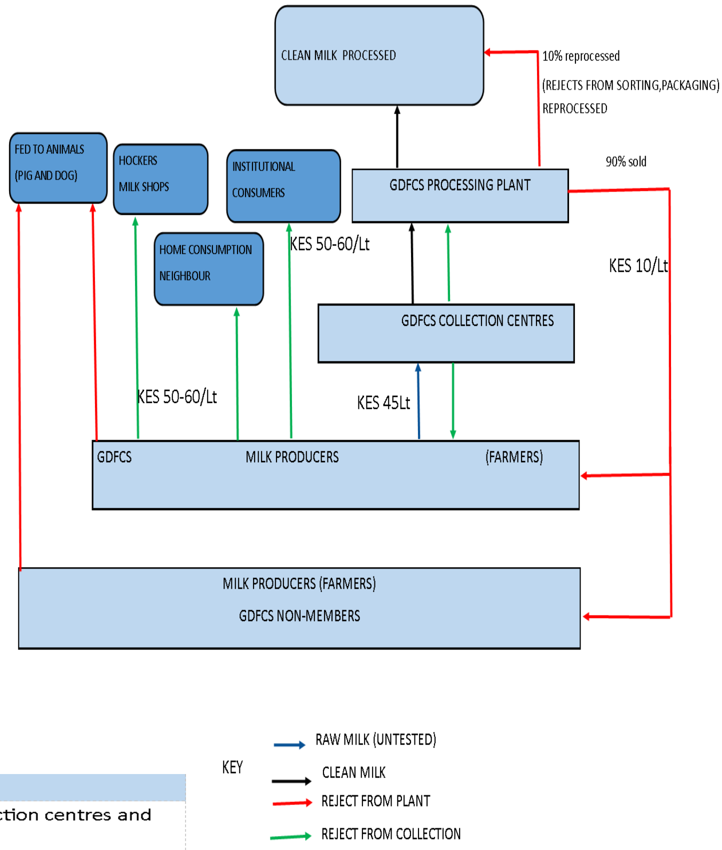


Figure 6: Milk chain of rejected milk



To summarise the Food Loss Audit, a SWOT analysis is made (Table 3).

Table 3: SWOT about the Food Loss Audit

STRENGTH	WEAKNESS
• Well organized and functioning dairy hub (GDFCS Dairy Hub) • Have Standard Operating procedures (SOP) • Presence of Milk quality standards for quality control • Good payment system that increase trust with farmers • Good record keeping for traceability • Cooling equipment for chilling milk collected before transportation to processing plant • Transportation of milk from farm to MCC by walking reduce GHG emission. • Educated staff • Good and active management team at all	• Milk losses at collection centres and processing plant • Poor milk handling during testing at collection centre

OPPORTUNITIES	THREATS
• Adopting farmers to technologies • Supporting Government (Policy and regulation) • Good access to infrastructure such as water and electricity • Increased consumption of processed products by consumers • The cooperative is located in town making easy to access the market from different cities like Nairobi	• Livestock disease such as Mastitis affecting milk quality • High electricity bill • Geographical location (more scattered farmers) • Weather condition (rain season affecting milk transportation) • Poor infrastructure such as road • Aged farmers • High transportation costs • High processing cost • High price of livestock feed (supplement feed)

Conclusion and recommendations

The cooperative PHL was quite low, but GDFCS was still not satisfied with the milk quality collected from the members (farmers). The lost, rejected, spilled and missing milk between short and long route were not significantly different. The milk loss at production level was high (94%) due to high percentage of milk loss (3.6%) of milk produced due to spoilage and spillage, in total about 2,380,500 lt/year FPCM. The estimated total economic loss from PHL at farm level was KES 107,122,500 annually (94%) and in the entire GDFCS milkshed KES 113,489,172 annually. The most common reason of PHL was mastitis incidence. The incidence of persistent mastitis at farm level gave the idea of coming up with the bucket milking machine. The Carbon Footprint in GDFCS milkshed due to milk losses was low thus contributing to 1.5% of the national Carbon Footprint. The milk disposal channels identified, especially feeding calves and home consumption, were not a good disposal channel as it causes health problem.

The easiest and cheapest interventions to implement include training and motivating staff and farmers, developing an information network, and making evening shift to permanent shift. The costliest interventions that need more investment (money and time) include establishing solar panel, milk test kits at farm level, simple bucket milking machines and quality-based payment system. Also, further research is needed at the national level to determine the extent of antibiotic residue and aflatoxin levels in the milk to make a better decision in reducing the cases of antibiotic residue and aflatoxin in milk.

Interventions developed based on the milk loss audit and the SWOT tool

Leverage point	Intervention	Focus area	Stakeholders involved	Stakeholders' roles
Production level (Most important)	Training	Feeds and feeding: good preservation of animal feeds, especially maize meal, and maize bran, drying or reducing moisture contents in animal feed (grasses and forages) without losing its nutritive value.	GDFCS extension officer, Training institutes, Quality Assurance Officer, and NGOs and FORQLAB project	Training and advisory services and Dissemination of technology
		Disease treatment and observation of withdrawal period: Proper dosage and avoiding self-treatment at farm level without consulting extensionists or vets.	GDFCS extension officer and vets KALRO	Training farmers and disease treatment Development and dissemination of technology
		Mastitis prevention measures	GDFCS and FORQLAB project	Training farmers Providing training material
		Establishing milk preservation or cooling method at the farm level: Putting more focus on spreading the technology of socking the milk bucket in clean and cold water for conservation and observing general milk hygiene. Also, training on milk quality assurance (HACCP) and good manufacturing practices (GMP)	GDFCS extension officer, Quality assurance officer and KDB. KALRO	Training farmers. Dissemination of technology (local storage technology and small milking

				machines) and training
	Introducing simple and affordable milking machine	Fermentation of evening milk is one way of adding value and extending the milk's shelf life.	GDFCS	Training farmers on milk fermentation
		Improving milk hygiene by introducing the use of milk machine in milking to reduce contamination and mastitis incidences	GDFCS, KALRO and FORQLAB project.	Ensuring accessibility of milking machines. Conducting research on simple milking machine economical to farmers.
Collection centre	Training staff	Increasing the training from once to twice per month to increase the awareness of the graders, inspectors and extensionists on current situations at the farm and, for example, training on milk handling during testing, measurement, and storage.	KDB, KEBS, KALRO, training institute and Quality assurance officer.	Training and creating awareness of the extent of milk loss at all levels of the value chain. Displaying the SOPs around the processing plant
	Motivation	Motivating farmers based on the quality of milk produced quarterly (every after 3 months) either by providing certificates of appreciation/recognition or other incentives.	GDFCS	Motivating farmers
	More attention on an evening or thrice milk collection shift	The evening shift should be made a permanent shift as the morning and afternoon shifts motivate farmers to focus more on the evening shift to reduce spoilage and rejection resulting from mixing the evening and morning milk.	GDFCS	Establishing evening shift
	Establishing solar power	Using solar power at the cooling point to reduce the electricity bill. Investing in solar power to reduce running cost and effect on milk quality due to power outage.	KDB GDFCS	Negotiating with the county government on behalf of the cooperative to get a loan or equipment/solar panel at a lower interest rate. GDFCS investing in solar power.

Processing level	Training staff	Appropriate preservation, processing technologies and milk hygiene during testing, measurement, packaging, and storage to avoid milk contamination and spillages.	GDCFC PLANT	Training and disseminating technology
GDFCS	Testing feed quality and good storage at the GDFCS store	Sourcing and selling dairy feed free from aflatoxin by ensuring the feed is tested before purchasing and ensuring good storage at the store or shop.	GDFCS, KALRO-Naivasha KEBS	Testing livestock feed Ensuring the livestock/dairy feeds sold meet KEBS standards.
	Promoting staff based on low incidences of mastitis in their working areas.	Extensionists and vets should be promoted or motivated by providing a certificate of recognition based on low or non- incidences of mastitis cases in their working area.	GDFCS	Promoting staff.
	Establishing a quality-based payment system	To improve the quality of milk sourced from the farm and reduce rejection, the cooperative should focus on buying and paying for milk delivered based on its quality rather than the volume.	GDFCS	Establishing a quality-based payment system.
		Providing incentives at the end of every six months to the farmer who supplies the milk that meets the GDFCS milk standards.	GDFCS	Motivating farmers to supply good quality milk.
	Development of Information network	Creating awareness among the dairy stakeholders on the general overview of PHL through the workshop, field visits/day and media campaigns (platforms, GDFCS and the national website) The players in the dairy sector and the public should be informed of the impacts of PHL for sound decision-making.	GDFCS, stakeholders involved in training and media.	Creating awareness on causes, the extent of losses and reduction strategies of losses.

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Accessibility of bucket milking machines to smallholder dairy farmers in Kiambu county Kenya to mitigate against milk losses and maintain quality

Njau Wanjahi Rimui, Robert Baars, Marco Verschuur,

Practice Brief
FORQLAB Project 2022-02

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

Smallholder dairy farmers are pushed to produce milk of good quality to meet expanding demand of milk and milk products (Nyokabi et al., 2019). Improper milk handling as well as poor hygiene and sanitation conditions cause milk contamination. Hand milking is considered as slow, tiresome and at times unhygienic with higher risks for diseases such as mastitis, which can be overcome by the use of milking machines. Milking machines have been available since the 1970s. However, the uptake has been poor and only a few farmers use them. 95% of the farmers milking by hand would like to acquire milking machines (Ombuna, 2018). The lack of working capital limits farmers' access to milking machines because they are costly and the majority of smallholder farmers cannot afford the purchase (Pambo, 2015). Furthermore, most microfinance institutions in Kenya lack a value chain approach that would aid smallholder farmers to adopt technologies, hence improving on productivity and quality of milk. The objective of this study was to assess the use, accessibility, financial services and perceptions of farmers of milking machines in relation to milk loss.

Methodology

The study was conducted in relatively well-develop peri-urban milk sheds in Githunguri and Kabete, in Kiambu county in Kenya, which borders Nairobi in the south. A total of 30 respondents were interviewed using a survey. They were grouped into farmers with milking machines (MM), farmers who had non-functional shelved machines (SM) and those willing to purchase but not having machines (WM). Each group had 10 farmers. Audio records from the interviews were transcribed for qualitative data. Observations on environment, equipment, milking protocol, and farm records were made during the 30 farm visits during milking. Comparison of means using ANOVA was used between and among MM, SM and WM using SPSS version 27. For the test in milk losses and milk production a Tukey post hoc test was used for comparison of means between groups. Face-to-face interviews among 12 finance, extension, research and marketing experts were also carried out.

Milk yield and milk loss

MM farmers had the highest milk production (410 l/d), the highest number of cows and highest yearly income from milk (Table 1). MM farmers had fewer milk losses and did not lose milk due to spillage, but in general for all farms milk losses were minimal (<0.5%). The major cause of milk losses were diseases, mainly mastitis, but also pneumonia and foot and mouth disease. The following statements were obtained from farmers:

1) Milking machines help ease load of work
2) They decrease turnover of workers
3) They reduce prevalence of mastitis within the herd

4) Milk coming off a milk machine has no contaminants and is clean
5) Workers can be able to attend to other duties for those with milking machines

The advantages of having milk machines were mainly observed for saving time for milking, and the lower turnover of workers on MM farms. The effect on the prevalence of mastitis was small. Milk losses as a result of contamination by dirt, flies or faeces and spillage were low.
SM and WM farmers had spoiled milk due to contaminants but milk losses were low. Milk spillage was observed due to the narrow opening in some milking containers, cattle kicking the milking can, or during transportation to the collection centre.

	MM	SM	WM
Milk yield per farm (l/d)	410[b]	217[a]	276[a]
- Milk delivered to cooperative (l/d)	379	184	244
- Milk sold aside from cooperatives (l/d)	9	15	13
- Milk for home consumption (l/d)	6	5	5
- Milk for calf feeding (l/d)	15	13	14
Milk yield per cow (l/yr)	4,773	4,043	4,071
Number of cows	24	15	19
Milk production per farm (l/yr)	114,552	60,646	77,352
Milk loss per farm (l/yr)	139[a]	221[b]	190[b]
- Milk loss due to diseases	139	194	156
- Milk loss due to spillage	0[a]	24[b]	32[b]
- Milk loss due to contamination	0	3	2
- Milk loss due to spoilage	0	0	0
Farm income (KES/yr)	5,154,840	2,729,076	3,480,836

[a,b,] Means with different superscripts within effect differ (P<0.05)

Table 1: Means of milk yield, milk use and milk loss. MM= farmers with milking machines (N=10), SM= farmers who had shelved machines (N=10), WM= farmers willing to purchase milking machines (N=10). KES = Kenyan shilling (45 KES/l).

Information on milking machines
MM farmers obtained much of their information from newspapers and magazines. Relatives and other farmers were an important source of information for all three groups. Trade fairs and agricultural shows were important for WM farmers.

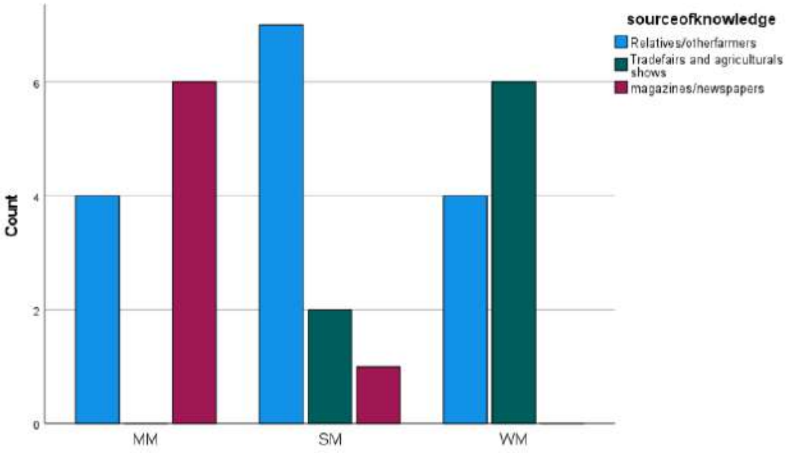

Figure 1: Source of knowledge on milking machines among farmer groups. MM= farmers with milking machines (N=10), SM= farmers who had shelved machines (N=10), WM= farmers willing to purchase

milking machines (N=10).

Farmers perception of milking machines

All farmers were asked to demystify myths and beliefs they had heard about milking machines from different sources. The following statements were brought to light by several respondents:

a) Milking machines milk blood from cows
b) Milking machines increase the rate of mastitis
c) Milking machines have an effect on udder shape and formation
d) Prolonged milking periods using milking machines causes teat erosions
e) Milk machines are costly to buy and maintain
f) Milk machines made for the African market are old models.

Several SM and WM farmers believed that milking machines increased the prevalence of mastitis. However, MM farmers believed they had no role in the increase in prevalence of mastitis, neither do the figures in Table 1 support any effect. Nevertheless, the belief that milking machines milk blood from cows, cause mastitis or damage the udder might influence the low adoption rate of milking machines.

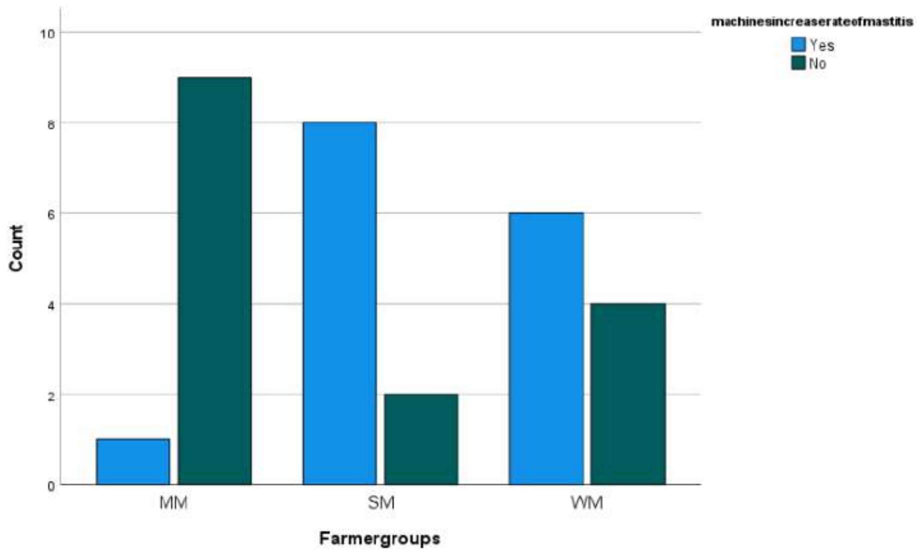

Figure 2: Perception of farmers on prevalence of mastitis using milking machines. MM= farmers with milking machines (N=10), SM= farmers who had shelved machines (N=10), WM= farmers willing to purchase milking machines (N=10).

Manufacturing countries of milking machines

Functional machines were purchased from agents with a home-base in France, Germany and India, whereas Turkish and Chinese machines had been shelved (Table 2). Farmers who had shelved machines gave the following reasons for not using them: 1) Machines could not be operated when the technical team left; 2) Lack of spare parts; 3) Increased prevalence of mastitis; 4) Theft. Farmers believed that milking machines brought into the Kenyan market are archaic in nature. Interviews with the research officer and director of KDFCS, extension officers and SM farmers confirmed that milking machine technologies offered in 1970s has not changed from what is being offered currently.

Countries where milking machines are manufactured	**MM**	**SM**

France	6	0
Germany	2	0
India	2	0
Turkey	0	6
China	0	3
USA	0	1

Table 2: Milking machines use and countries manufactured. MM= farmers with milking machines (N=10), SM= farmers who had shelved machines (N=10).

Hygiene practices

Farmers from all groups practiced hygiene and safety measures to ensure milk quality. However, some parameters such as washing hands with water and soap before milking, washing and drying teats before milking and proper storage of milk salve in a sealed container were not always enforced:

a) Seven out of 10 MM farmers had washing sinks equipped with soap (Table 3). Despite 6 SM farmers having washing sinks, not all used them. Only two WM farmers had wash sinks.
b) The MM farmers used teat dips most often, whereas WM farmers seldom use teat dips.
c) Coloured milk test (CMT) was rarely used. The WM group had a highest number of farmers using CMT.
d) Most farmers never or seldomly checked the colour or appearance of milk using a strip cup. SM and WM farmers who had no strip cup checked the appearance of the milk using the palm of their hand.
e) Farmers seldomly or at times used two towels, one to clean the udder and the other to dry, instead they used one towel to clean and dry the udder.
f) Most farmers did not seal and kept the milking salve in cool and dry conditions. In most cases the milking salve was left open.
g) Washing the milk parlour was done by most farmers.
h) Most WM and SM farmer ensured to strip off all milk from the cow after milking. Some MM farmers would milk completely thus no need of stripping off.

	MM				**SM**				**WM**			
	NE	SE	SO	OF	NE	SE	SO	OF	NE	SE	SO	OF
a) Hand washing before milking			1	9	1		4	5			3	7
b) Teat dips		1	3	6	1	3	3	3		4	2	4
c) Coloured milk test	5	3	1	1	7	2	1		3	3	1	3
d) Use strip cup	4	3	1	2	6	3	1		4	2	1	3
e) Use of two towels		5	5		1	3	6			6	3	1
f) Milking salve stored cool/dry	8		1	1	8	2			1	5	3	1
g) Washing milk parlour		2	4	4	1		3	6		1	5	4
h) Stripping teats		1	4	5	1		2	7			2	8

Table 3: Milk hygiene practices. MM= farmers with milking machines (N=10), SM= farmers who had shelved machines (N=10). NE = never, SE = seldom, SO = sometimes, OF = often.

Financial services

Equity Bank, K Unity Microfinance, GDC Sacco Society and Kabete Sacco offered financial products accessible to dairy farmers, though they were not all tailor-made for agriculture. The financial institutions interviewed had a limited knowledge of milking machines but were interested in promoting their products to farmers. Milking machines companies did not have a direct contact with banks and offered their products through cooperatives.

MM and SM farmers would not advise WM farmers to take a loan to purchase a milking machine. If loans were accessed, they could be used for other priorities.

Dairy cooperatives both in Githunguri and Kabete sub counties had good working relationships with financial institutions. Farmers in both cooperatives did not have their own milk records thus were dependent on delivery records to cooperatives for access of credit.

Conclusions

- Milk losses were low, less than 0.5% of the total milk yield, which does not say much about the quality of the milk. To assess the effect of milking machines on milk quality, milk testing is required, which was not available in the study area.
- Farmers with milking machines produced more milk, but it cannot be concluded whether more milk was produced because of machines, or whether the presence of more cows motivated the use of machines.
- Other reasons than milk quality motivated the use of milking machines, and the motivation to purchase them among those not using machines seems low. Better financial services are not likely to change that.
- Milking machines used by farmers in the study were old models. European and Indian machines with availability of spare parts showed better performance.
- There is a lot to win with stricter compliance to hygiene practices. Some practices were well implemented, others not.
- While there are linkages between the farmer and financial institutions through the cooperative to access credit, milk machine companies have not taken advantage by creating partnerships to offer their products. This can be done by coming up with a business model which would promote milk machines. Farmers would rather not take credit to purchase milking machines. They would rather focus on increasing milk production and purchase machines from those proceeds or through savings.

Recommendations

To enhance adoption of milk machines, its recommended that: 1. Extension officers both in government and cooperatives work together to train masses on the benefits of milk machines; 2. Financial institutions, milk machine companies and cooperatives set up credit groups of farmers willing to access quality milking machines whereby access to credit would be easier than individual farmers.

Interventions to promote access to milking machines should focus on:

- Promotion of milking machines
- Training and extension
- Developing a business model for sales agents (Figure 3)
- Setting up demo farms
- Promoting access to credit

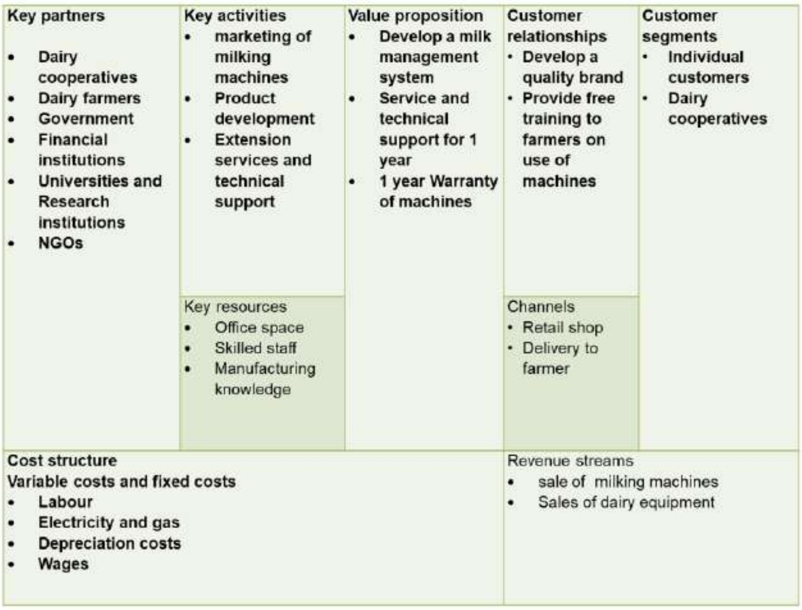

Figure 3: Canvass business model for milk machine companies

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Food Loss Along the Dairy Value Chain:

A Case Study of Kitinda and Kaptama Dairy Farmers’ Cooperative Societies in Bungoma County- Kenya

Mercy Jerop Kemboi, Marco Verschuur, Robert Baars

Practice Brief
FORQLAB Project 2022-03

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

Milk and milk products account for approximately 21% of global food losses, with annual after-harvest milk losses ranging from 10% to 23% (Gustafsson et al., 2013; FAO, 2011). These losses are more prevalent in developing countries like Kenya (Gromko et al., 2019). Milk loss is commonly caused by milk rejection, spillage, and contamination. Milk losses are not only a missed economic opportunity, but also a waste of all-natural resources used in production, processing, packaging, transportation, and marketing, all of which contribute to greenhouse gas emissions measured in kilograms of CO2-equivalents (carbon footprint) (FAO, 2011). As a result, in this study the economic and carbon footprint of actual milk losses along the dairy value chain in Bungoma County, Kenya, was measured and compared between Kitinda and Kaptama Dairy Farmers' Cooperative Societies.

Methodology

A comparative study of milk loss along the smallholder dairy value chain was conducted in Kitinda and Kaptama Dairy Farmers’ Cooperative Societies in western Kenya, a relatively weak-developed formal chain. A semi-structured questionnaire was given to 40 smallholder dairy producers, 20 from each cooperative, and the survey results were discussed in focus group discussions (n=16) per cooperative. Furthermore, 14 key informants among the Kitinda and Kaptama value chains were interviewed one-on-one, with video and audio recorded and notes taken. The transcription of qualitative data was analysed by reviewing interviews, focus group discussion notes, and audio recordings. Quantitative data was also analysed descriptively and inferentially (in SPSS version 27) using frequencies, percentages, means, and standard deviation. A comparison of the findings of the two cooperatives was presented using tables and charts.

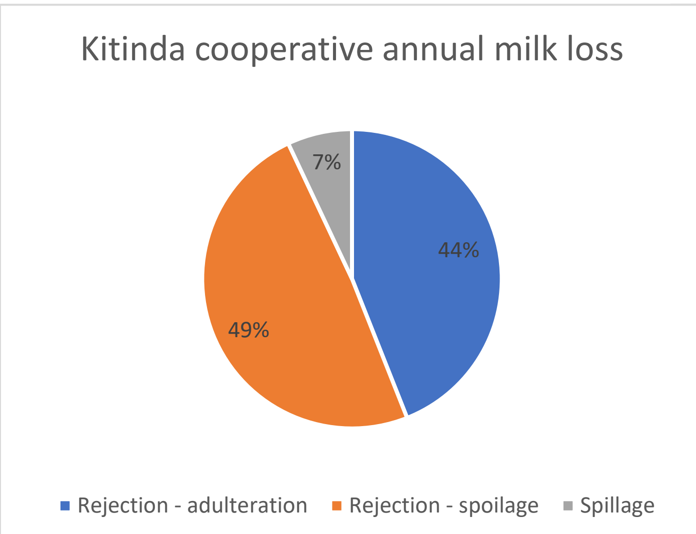
Food loss share per cooperative

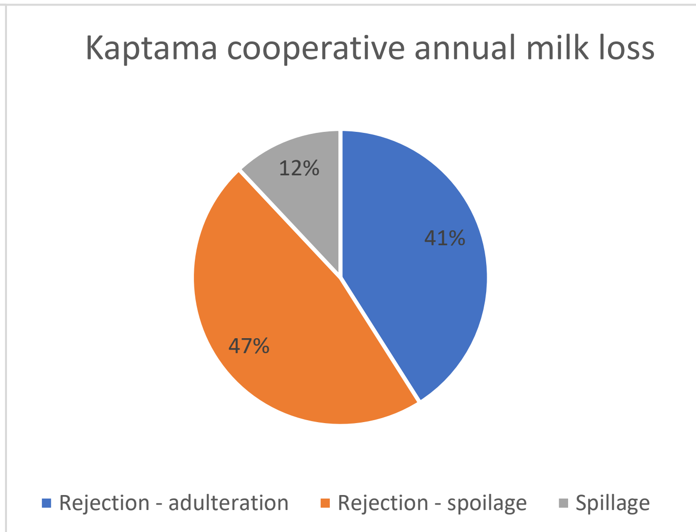
At cooperative level, the recorded level of milk rejection was much higher than milk spillage. Spillage contributed the least to milk losses in Kitinda and Kaptama, accounting for 7% and 12%, respectively.

Kitinda has the highest spoilage rejection rate (49%), while Kaptama has the highest adulteration rejection rate (47%) (Figure 1).

Kitinda milk spoilage was attributed to the mixing of morning and evening milk and the distance between collection points and cooperative points, which can be up to 10 kilometres. However, milk spoilage is high during the wet season due to poor farmer hygiene and long collection times of up to 3 hours due to poor roads. In contrast, Kaptama has a high rejection rate (water adulteration), and due to the processor's strict rules on milk density testing, milk is only accepted if the lactometer reading is between 1.028 and 1.030 mg/l; anything above or below that range is rejected.

Figure 1: share of milk losses at the cooperative level





Food loss economic value along the dairy value chains

Kitinda cooperative's total food loss share revealed the lowest milk loss of 850,000 KES (7%) at production level, whereas at cooperative and processing levels losses were 5,850,000 KES (51%) and 4,800,000 KES (42%), respectively, as a result of Kitinda doing self-milk processing with low adherence to quality standards (Table 1). The cooperative's losses were attributed to high milk rejection, whereas processing losses were attributed to infrastructure issues such as milk contamination by the processing dispenser and power outages.

Table 1: Kitinda food loss share

Function	Total milk loss / year [Liters]	Loss [%]	Mean Price [KES]	Economic value [KES]	Milk loss share [%]
Production	25,000	12	34	850,000	7
Cooperative	130,000	60	45	5,850,000	51
Processor	60,000	28	80	4,800,000	42
TOTAL	215,000	100		11,500,000	100

Total Milk loss = ∑production losses + ∑collection/Cooperative losses+∑Processing losses

The **Kaptama** cooperative's total food loss share was lowest at processing level with 384,000 KES (8%), whereas at production and cooperative level milk losses were 771,120 KES (17%) and 3,515,400 KES (75%), respectively (Table 2). This is due to Kaptama's collaboration with a private company (Brookside) to process their milk; as a result, they strictly adhere to the processor's milk quality standards for milk received, resulting in more rejection at the cooperative level.

Table 2: Kaptama food loss share

Function	Total milk loss / year [liters]	Loss [%]	Mean Price [KES]	Economic value [KES]	Milk loss share [%]
Production	22,680	22	34	771,120	17
Cooperative	76,860	73	45	3,515,400	75
Processor	4,800	5	80	384,000	8
TOTAL	104,340	100		4,670,520	100

Total Milk loss = ∑production losses + ∑collection/Cooperative losses+∑Processing losses

Impact of milk loss on Carbon Footprint (CF)

Kitinda and Kaptama, respectively, had carbon footprints of 230,809 and 112,010 kg CO2-eq. per year. If this concept is applied to the national carbon footprint, both cooperatives would contribute 0.001% of the national CF (Table 3). Even though the figure is significantly lower, long-term milk production strategies to reduce it should be implemented because production per cow is lower, resulting in higher carbon emissions.

Figure 3: Carbon foot of Kitinda and Kaptama milk loss [kg CO_2 eq.]

Cooperative	Total annual CF of milk loss	Total annual CF of milk loss in Kenya	Total CF % contribution
Kitinda	230,809	12.3 million	0.00002
Kaptama	112,010	12.3 million	0.00001

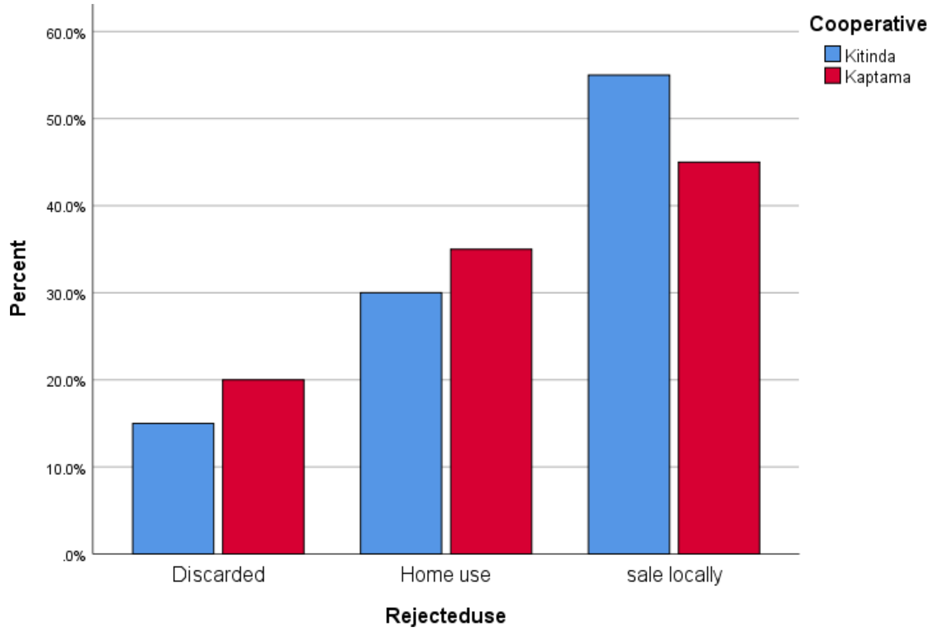
Governance

Kaptama is considered to have a solid governance structure in terms of chain robustness, dependability, and resilience. Kitinda, on the other hand, has weak chain links, market institutions, chain coordination, and farmer organizations. The viability of Kaptama's cooperation with Brookside may be linked to its excellent governance.

Destination of rejected milk at MCC, Cooperative and Processing Level

Rejected milk finds a way to market or is repurposed, as shown in Figure 2. Milk rejected during production due to water adulteration is sold locally, either to neighbours or hotels. The milk was either fed to animals, sold to pig owners, or used to make fermented milk if they are rejected due to milk spoilage.

Figure 2: Destination of rejected milk per cooperative.



Current Milk Loss Reduction Strategies

chain level	Current strategies employed	Challenges
Milk production level	Proper cleaning of milk containers Maintaining hygiene Avoiding the mixing of morning and evening milk Proper storage of milk	Low milk prices Inadequate funds to buy certified milk cans Use of uncertified food-grade plastic containers in milk transportation

Milk collection / cooperative level	Capacity building on clean milk production Collection of milk in early morning Chilling of milk	Mixing milk from different farmers at the collection centre Use of plastic cans in storage andtransporting milk Poor transport network Prolonged delivery of milk tocooperative Water adulteration malpractices Insufficient funds to purchase adequate testing equipment Impassable road network Lack of cold chain at collection points Nonfunctional milk equipment Power shortages Less sophisticated testing milk kits Raising quality standards by processors inwet season
Processing level	Capacity building for staff and farmers	Mechanical breakdown of processing equipment Power shortages Lack of refrigerated trucks

Milk loss reduction obstacles

Aside from the efforts of both cooperatives to reduce milk losses, several challenges were identified, such as:

- High milk production costs
- Inadequate financial resources at collection centres or cooperatives to purchase sufficient milk equipment, such as milk testing kits and transport/storage milk cans.
- Poor infrastructure, including road networks, equipment, electricity, cooling, and processing facilities, as well as a lack of ICT adoption.

Conclusions

➢ Kitinda incurred higher losses at both processing and cooperative levels, but Kaptama sustained more losses at cooperative and production levels. This is most likely due to Kitinda doing self-processing while Kaptama distributes milk to Brookside for processing.

➢ Kitinda experienced a total milk loss of 215,000 annually costing KES 11.5 million with KES 0.9 million (7%) at production, KES 5.9 million (51%) at cooperative, and KES 4.8 million (42%) at the processing level. While Kaptama milkshed calculated a total of KES 104,340 milk losses worth KES 4.7 million (17%) with 0.8 million (17%) at production, KES 3.5 million (75%) at cooperative, and 0.4 million (8%) at the processing level.

➢ Kitinda and Kaptama contributed to a CF of 230,809 and 112,010 kg CO_2 eq., respectively. Both cooperatives provide 0.001% of the country's total CF. This clearly shows that milk loss adds a negligible amount of carbon impact to the yearly carbon footprint.

- All losses experienced along the dairy value chain were losses to the cooperative rather than losses to the food system, because all milk rejected is eventually sold or fed to animals.
- Kaptama was considered to have a solid governance structure in terms of chain robustness, dependability, and resilience. Kitinda, on the other hand, had weak chain links, market institutions, chain coordination, and farmer organizations. The viability of Kaptama's cooperation with Brookside may be linked to its excellent governance.
- Current strategies used to reduce milk loss identified along the Kitinda and Kaptama dairy value chains included:
    - Keeping hygiene
    - Separating morning and evening milk
    - Proper storage of milk
    - Training of farmers on the production of clean milk
    - Cooling immediately after milking

Recommendations

It is strongly advised that both cooperative societies collaborate with financial institutions, start collecting evening milk and selling it to informal markets, and establish Savings and Credit Cooperative Organizations (SACCOs) to reduce milk losses. Kitinda was also urged to collaborate with Brookside as their processor, whereas Kaptama was recommended to strengthen farmers in order to deliver quality milk.

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Clean Milking for Safe Milk

Tom van Melick, Jo-Anne Voort, Daan Westrik

Practice Brief
FORQLAB Project 2022-09

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

AERES UNIVERSITY OF APPLIED SCIENCES

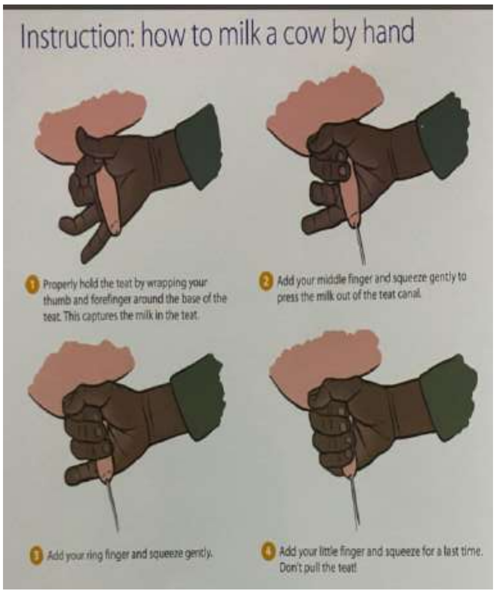
Purpose
Since milk losses have a major economic and carbon footprint implication the purpose of this study was to identify milk losses at the different stages of the smallholder dairy value chain in Bungoma County.

Method
This study took place in Bungoma County studying the value chain of two dairy cooperatives: Kaptama Dairy Farmers Cooperative Society and Kitinda Dairy Farmers Cooperative Society.
Students of Aeres University of Applied Sciences visited the different actors of the value chain and observed milk production and handling activities to identify loss of quantity and quality of milk.

Cooperatives
Kaptama Dairy Farmers Cooperative Society started in 1958 in Mount Elgon Sub County as a cooperative owned by dairy farmers. The dairy cooperative then ceased to exist after twenty years. Twenty years later, the World Bank rebuilt and reopened the society through one of its local development arms, the Western Kenya Community Driven and Flood Mitigation Programme.
This dairy cooperative involves 1260 farmers who supply the milk to the cooperative. On average, 3,800 litres per day are delivered in the wet season and at least 600 litres per day are delivered to the cooperative in the dry season. The fresh milk is cooled and then transported to Brookside Dairies, one of the largest milk processing companies in Kenya with a 45% market share.
Kitinda Dairy Farmers Cooperative has been established in 1957 as a disease control station. Later it was turned into a milk transit station. In 1986 the Finnish government started investing in the milk transit station. In the best years the station processed 16.000 litres of milk per day and had 9.000 members. After the Finnish investors left in 1989, the following board members were unable to manage the station. Resulting in it going bankrupt in 1995. During the time between 1995 and 2013 several company`s tried to invest in the station and make it profitable but all failed to do so. In 2013 the government revived the station.
Currently the Kitinda Dairy Farmers Cooperative Society has 1.000 members, including 550 women, 380 men and 70 young people. The cooperative collects 8.000 litres of milk every day. 16 different collection centres bring the milk to the cooperative. The cooperative makes multiple products from the milk they receive from the farmers, such as yoghurt, cheese, and mala (fermented milk). They also sell the milk pasteurized to hospitals and milk venders.

Main findings for Kitinda
Possible factors related to potential milk loss (quantity and quality) in the different stages of the milk production and transport and collection are identified.

At the level of te dairy farm
Most of the farms visited have one or two cows with a production of around 5 litres per cow. Most of the farmers apply hand milking. Udders are cleaned with warm water and a cloth in most cases. Udder creme is used to soften the teats. Plastic jerrycans are used for milk storage.
About one fifth of the farmers doesn't have knowledge about mastitis and tests for testing on subclinical mastitis are not available.



Advice about milking techniques:
Advice therefore includes the application of proper milking techniques like cleaning of the udder using dry cloths and using disinfectants after milking, use of stainless-steel buckets and proper cleaning methods for milking equipment. Improving milk collection using a sieve and cooling and/or transport to the milk collection centre immediately.
Advice about mastitis:
Ensure a minimum length of the dry period of two months and apply hygienic milking procedures: workplace and equipment, udder cleaning and clean hands before milking.
Make use of the Californian mastitis test te detect subclinical mastitis and use udder ointment for light infections or apply antibiotics, if possible, for severe cases.

At the level of transport farmer to collection centre
The morning milk is collected at the milk collection points and transported to the cooperative cooling centre by means of plastic jerrycans. Evening milk is brought to the collection point in the morning or used for home consumption. Plastic jerrycans used for transport are cleaned with warm water and soap. Sometimes sand is added for better cleaning.
Advice includes. Collection in morning and evening to enhance timely cooling of the evening milk. Use of stainless-steel buckets and use pressure cleaning and application of disinfectants like chlorine is advised.

At the level of transport collection centre to cooperative
Before ten o'clock all the milk has been arrived at the collection's points, because the transporters from the collection centre must be at the cooperative before 11 o'clock otherwise the cooperative will reject the milk.
Quality control at the cooperative consists of density tests to check on dilution with water after which the milk is sieved and stored but not cooled for sales to consumers. The remaining part is pasteurized before it's processed in mala.

For hygiene reasons, it is advised to start using stainless-steel buckets instead of the plastic jerrycans.

Quality tests
Milk is tested for dilution with water by using a lactometer at the level of the milk collection centre and cooperative. At the milk collection centre, the milk is tested for smell and taste.
The advice is: improve the hygiene of the laboratory and add checks for milk quality starting with measuring the bacterial count. But also, mastitis detecting by using somatic cell count is recommended.

Conclusion
The main topics that emerged are proper milking techniques and tools, mastitis prevention and treatment. Collection and cooling of evening milk, cleaning and disinfection of plastic jerry cans or use of stainless steel. Improvement of milk quality test and laboratory facilities.

Main findings for Kaptama

Possible factors related to potential milk loss in the different stages of the milk production and transport and collection are identified.

At the level of the dairy farm

In most cases pre-treatment before milking is done with warm water and a cloth. Udder creme is often applied to the teats to make milking easier. Warm water is easy to use and affordable. is cheap. Not many farmers disinfect the teats before or after milking, this is because disinfectant is considered as to expensive. After milking the milk is stored into plastic jerrycans and brought to the milk collection centre or cooperative. The jerrycans are cleaned with hot water and sometimes soap is used. However, jerrycans are difficult to clean properly.

Most of the farmers know about mastitis but they only know about clinical mastitis. Most of them are not testing for subclinical mastitis because they don't have knowledge about this type of mastitis and/or they don't have the right tools available to detect this type of mastitis. According to the farmers, they call a veterinarian for treatment in case of mastitis. There are only a few farmers who take independent steps to combat mastitis.

<u>Advice</u> therefore includes the application of proper milking techniques like cleaning of the udder using dry cloths and using disinfectants after milking, use of stainless-steel buckets and proper cleaning methods. Improving milk collection using a sieve and cooling and/or transport to the milk collection centre immediately.

<u>Advice about mastitis</u>:

Ensure a minimum length of the dry period of two months and apply hygienic milking procedures: workplace and equipment, udder cleaning and clean hands before milking.

Make use of the Californian mastitis test te detect subclinical mastitis and use udder ointment for light infections or apply antibiotics, if possible, for severe cases.

At the level of transport farmer to collection centre

The cooperative has 15 collection centres. After milking, 73% of the farmers take the milk to the cooperative or milk collection centre in the morning only. Evening milk which is brought in the morning is combined with morning milk at the milk collection centre. Starting at 8.00 hrs the milk is collected at one of these centres and checked on dilution with water. The milk is also tested for smell and taste. About 20 litres of milk per day is rejected. After weighing the milk, it is stored in stainless steel cans of 50 litres. The milk is not cooled but stored in the shade. After 10.30 hrs the collected milk is transported to the cooperative using motorbikes or by foot. Conditions during transport (duration and temperature) are not in favour of hygiene. Travel distances are between one and two hours.

Jerrycans which are used for transport are cleaned with water. No warm water or disinfectant is used to clean the equipment.

<u>Advice</u> includes. Collection of milk in morning and evening to enhance timely cooling of the evening milk. Use of stainless-steel buckets and use pressure cleaning and application of disinfectants like chlorine.

At the level of transport collection centre to cooperative

At the cooperative the milk is again tested for dilution with water with a density meter and stored in a milk tank of 3000 litres. The milk is stored at around 12 degrees Celsius.

<u>Advice:</u> apply proper cleaning of equipment using warm water for pre-cleaning, hot water for cleaning and cold water for post cleaning. Use appreciated cleaning solutions and disinfectant.

Improve cold storage at the different stages: cooling down the milk directly after milking, reducing time between milking and cooling at the milk collection centre or cooperative. Store in a cooling tank at around 4 degrees Celsius.

Milk quality

At the collection centre, the density is measured with a lactometer, also smell and taste is checked. At the cooperative the density test is performed again. Als the resazurin (bacteria count), antibiotics test and density meter (solids) are available at the cooperative. The acidity meter (sour milk) is available but not functioning.

<u>Recommendations are</u>:
Make sure that milk from every farmer is tested for mastitis so that the farmer is immediately informed of a mastitis problem and the milk is not mixed with milk from others. Performing bacterial culture for the milk of every farmer is a recommended next step.
Be consistent in testing for dilution with water and collect evening milk to assure proper filtering and cooling. Improve laboratory facilities with focus on hygiene and proper functioning of equipment.


Figure 2: Labratorium Kaptama dairy cooperative

Milk spoilage
At the cooperative and milk collection centres together the estimated milk spoilage is between 160 – 200 litres per day. This is 8% to 10% of the total amount of milk collected. Some milk collection centres have a spoilage percentage of 20% per day others only 5%. The amount of spoilage increases when new farmers start delivering which have no knowledge about correct milk preservation. The spoiled milk is not used for other purposes but disposed. Disposed milk is not paid for. Reasons for milk spoilage are:
- The milk has been too warm for too long, resulting in the milk getting sour.
- The evening milk is combined with the morning milk, resulting in the milk getting sour.
- The milk contains cloths due to mastitis

Conclusion
The main topics that emerged are forage harvest, forage quality, breeding, milk production, milk price and agricultural innovations.

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TRANSPORT OF MILK – FROM FARM PRODUCTION TO PROCESSING A case study of Fresha Dairy Brands, Kenya

Linda van der Broek, Daan Westrik, Marco Verschuur

Practice Brief
FORQLAB Project 2023-10

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

In 2004, Githunguri Dairy Farmers Co-Operative Society (GDFCS), also known as Fresha Dairy Brands, started operating its own milk plant which increased the profitability and size of the organization (Fresha, 2022). In 2022, the cooperative has a total of 27,500 members, of which 11,700 are active. Eighty percent of Fresha's members are small-scale dairy farmers with a range of one to five cows. Many of these farmers struggle with low milk yields per cow of on average eleven (11) liters per cow per day, relatively low milk quality and low profitability. Due to insufficient knowledge and inadequate infrastructure, many small-scale farmers depend strongly on Fresha to supply their milk to this dairy cooperative.

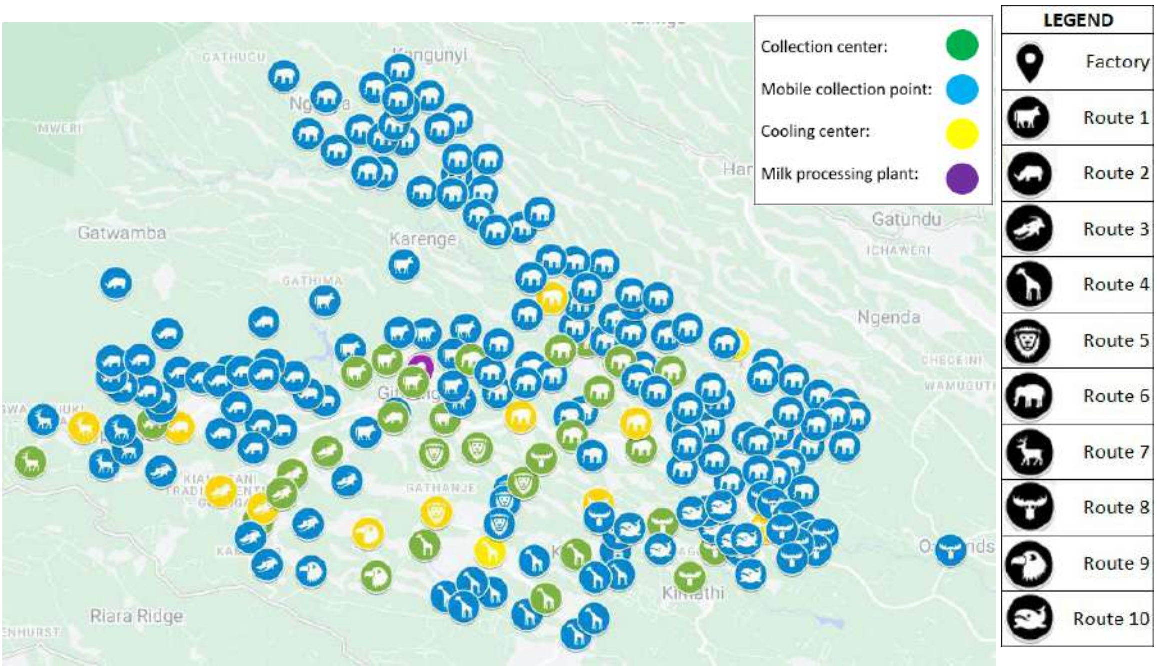
Currently, the milk quality of Fresha is poor due to a lack of knowledge, poor infrastructure (roads), and uncooled transport. The organization wants to improve the raw milk collection. Due to high transport costs and quality losses, GDFCS wants to make this process more efficient. In 2022, the average transportation cost for raw milk was 2.63 KES per kg of milk. This study's research question was: 'How can Githunguri Dairy Farmers Co-Operative Society increase the efficiency and decrease the costs of transport within the supply chain, from farm production to processing, to increase profitability in 2023?'

Githunguri Milkshed

In Githunguri, the subcounty where Fresha is located, 95% of the milk produced was part of the formal chain and delivered to Githunguri Dairy Farmers Co-Operative Society; 5% of the milk market was part of the informal sector (McDonald, pers. comm.). In total, Fresha had 13 cooling centres, 49 collection centres and 151 collection points and the milk processing plant, distributed along 10 different routes (Figure 1). A **collection centre** was a building made of bricks where milk was collected in aluminium cans that are cleaned and/or stored at this location. The grader and attendant came by themselves to this location. After collection, the grader waited with the attendant for the truck to ensure that all milk that had been collected, had been picked up, which then have been transported to the processing plant. A **collection point** was a building made of wood to which dairy farmers brought their milk, waited for a truck with the grader, assistant, and milk cans.

Depending on where the collection points or collection centres were located and the milk volume, the raw milk was taken to one of the 13 cooling centres. Only the raw milk of route 1 was taken directly to the milk processing plant. The milk of the other routes was transported to the milk processing plant after being cooled in one of the cooling centres.

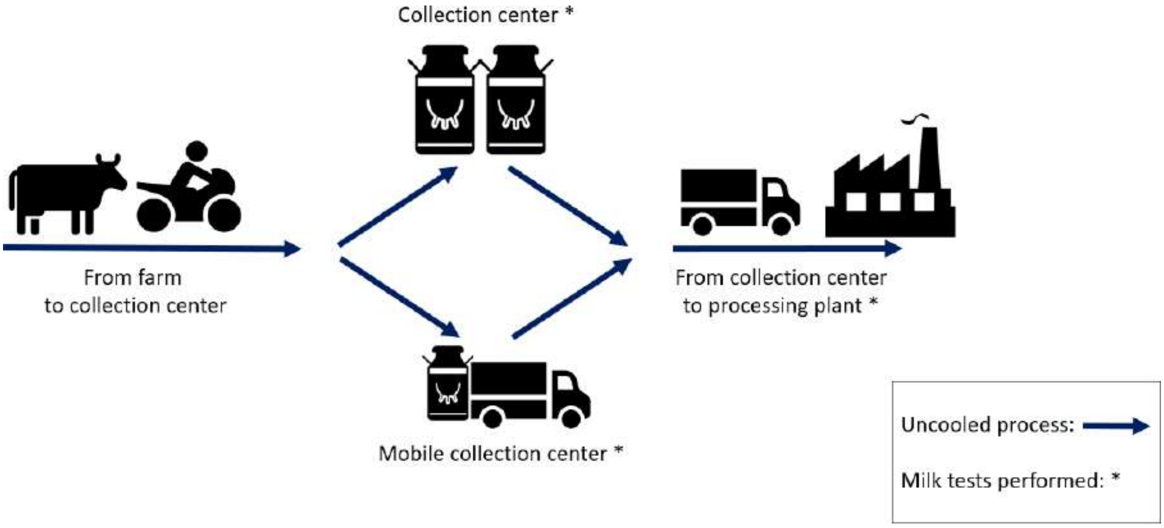
Figure 1: Digital map of locations of (mobile) collection centres, cooling centres, and the processing plant.



Short and long supply chains

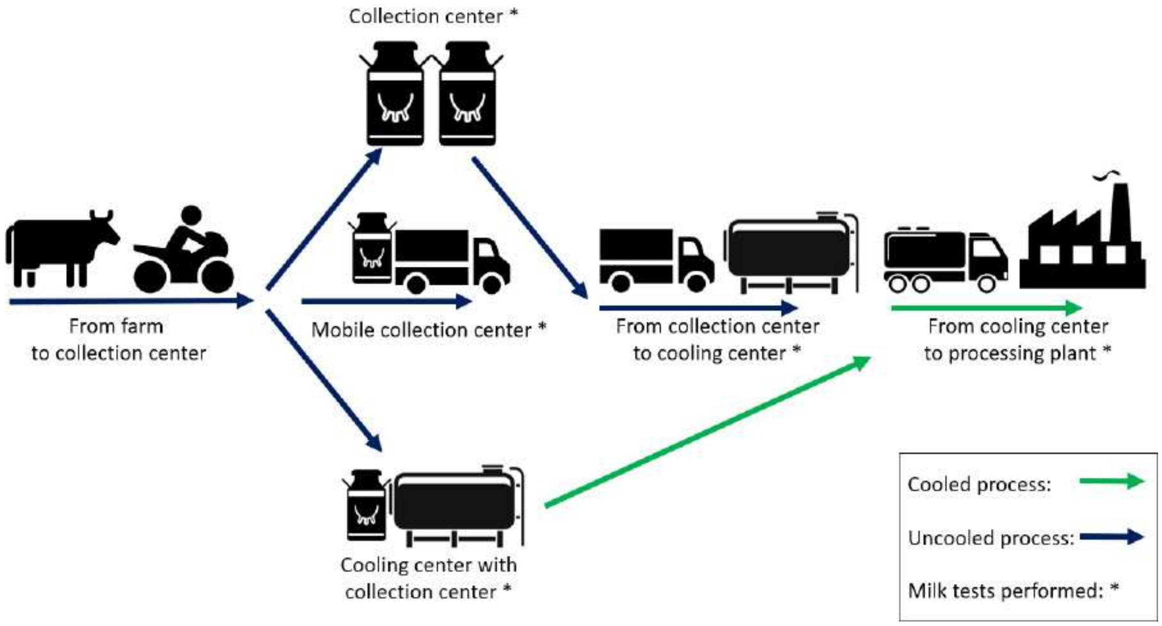
This research showed that the milk supply chain of Fresha can be divided into a short and long chain. Fresha's short milk supply chain is as follows: dairy farmers bring the milk to a collection centre, or a mobile collection point, where the milk was collected and then directly transported to the processing plant. The short supply chain was present in the areas close to the milk processing plant (Figure 2).

Figure 2: Fresha's short milk supply chain.



Fresha's long milk supply chain had an additional stop and was as follows: dairy farmers brought the milk to a collection centre or a mobile collection point, and then it was taken to a cooling centre. Another option was bringing the milk directly to a cooling centre which includes a collection centre. At the cooling centre, the milk was cooled for several hours before being transported to the processing plant. The long supply chain was present in the areas further away from the milk processing plant (Figure 3).

Figure 3: Fresha's long milk supply chain.



Githunguri Dairy Value Chain

GDFCS member farmers delivered their cow milk twice a day. The size of the dairy farms and the amount of milk produced determined the method of milking (Figure 4). The left picture showed a farm with 2 cows which were milked manually. The middle picture was taken on a farm with 15 cows and employees milked by hand. The right image showed a farm with 35 cows where the employees milked with a milking machine.

Figure 4: Different milking methods at Fresha members' dairy farms.

After milking, the farmer brought the unrefrigerated milk in aluminium milk cans to the nearest collection centre, either a collection centre (Figure 5) or a mobile collection point (Figure 6).

Figure 5: Fresha's collection centre.

Figure 6: Fresha's mobile collection point.

The farmers transported the milk to a collection centre or point by foot, wheelbarrow, bicycle, motorbike, donkey carts or car (Figure 7). On average, farmers were located within 1.5 to 2 kilometres from the nearest collection point.

Figure 7: Fresha's members transporting raw milk.

Figure 8: Performance lactometer and alcohol test.

Upon receiving at a collection point, milk from the dairy farmers was tested by the grader to assess the quality of the milk. At this stage of the chain, the following tests were performed (Figure 8):

- <u>Lactometer test:</u> Checked the density of the milk; every milk can individually.
- <u>Alcohol test:</u> Checked the stability of milk proteins; every milk can individually.

If the milk had a density between 27 L.R to 32 L.R and no flakes or skim appear while doing the alcohol test, the milk was accepted. If the milk failed the tests, the dairy farmer was sent home with the milk. In case of continuing failed results, a Dairy Extension Officer (DEO) was sent to the concerning farm to investigate the cause.

Figure 9: Farmer pouring raw milk in Fresha's milk can and PIMPAPP linked to the weighing scale.

After approval of the milk, the farmer then pours the milk through a filter, into an aluminium milk can owned by the cooperative, with an identical number. This milk can is connected to a weighing scale, which is linked to an app, called PIMPAPP that uses the identical farm number to register how many kilograms of milk the farmer has brought in (Figure 9). The identical milk can number is also recorded to trace which milk belongs to which farmer. In case of rejection, it is possible to find out from which farmers milk is in a specific can.

After all the milk has been collected in a collection centre, the full milk cans were put together, and the grader noted the number of cans collected and records the amounts [in kg] for the administration. In this way, it was checked whether the amount of milk collected corresponded with the amount of milk processed at the plant. The grader then waited with the attendant for the truck to ensure that all collected milk had been picked up to be transported to the processing plant (Figure 10). Depending on the route, trucks collected milk cans at several collection centres before unloading at the processing plant. In case of a mobile collection point, the full milk cans were loaded directly in the truck and went to the next mobile collection point. After completing the mobile route, the truck transported the milk to the processing plant.

Figure 10: Loading the truck with milk cans to transport them to the processing plant.

Upon arrival at the plant, the milk was tested again to assess the quality of the milk. At this stage of the chain, the following tests were performed:

- <u>Lactometer test:</u> Checked the density of the milk; every milk can individually.
- <u>Alcohol test:</u> Checked the stability of milk proteins; every milk can individually.

If the milk showed a density between 27 L.R to 32 L.R and no flakes or skim appeared while doing the alcohol test, the milk was allowed to continue in the process. When approved, the milk cans were manually emptied, and the milk processing started (Figure 11). In case of rejection on arrival, the milk was not processed and sold as pig feed. Reasons for rejection after collection were souring of milk due to long transportation / problems along the way, hygiene of Fresha's milk cans and incomplete execution of tests during milk collection.

Figure 11: Unloading milk cans at the processing plant.

In case of the milk collected at a cooling centre with collection facility, the milk was cooled directly after being received. Upon arrival at the cooling centre, the milk was tested to check whether the milk is free of antibiotics, aflatoxins, and neutralizers, such as sodium bicarbonate, which can alter the composition and modify the quality of the milk. In this stage of the chain, the following tests were executed:

- Lactometer test: Checked the density of the milk; every milk can individually.
- Alcohol test: Checked the stability of milk proteins; every milk can individually.
- Antibiotics test: Checked if antibiotics were present in the milk; bulk milk cooling tank.
- Aflatoxins test: Checked if aflatoxins were present in the milk; bulk milk cooling tank.
- Neutralizers test: Checked if neutralizers were present in the milk; bulk milk cooling tank.

If approved, the milk cans were manually emptied and pumped into the cooling tank (Figure 12). At the cooling centre the milk was stored for several hours and cooled to an average of 7°C.

Figure 12: Emptying milk cans and pumping the milk into the cooling tank.

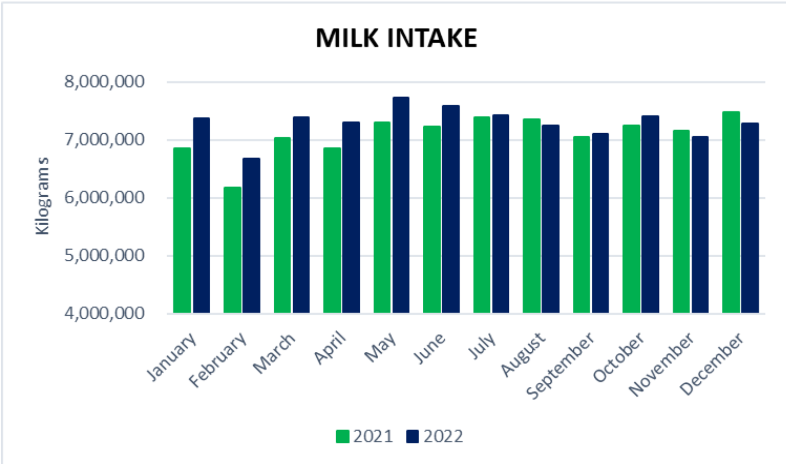
Since the dairy farmers delivered milk twice a day, the milk tank was also emptied twice a day and pumped into a tanker truck with a capacity of 10 or 11 tons of milk (Figure 13). Loading the tanker took about 45 minutes after which the truck drove to the processing plant. Upon arrival at the processing plant, the raw milk in the tanker was tested again, to monitor the milk after every transport movement and to ensure the quality of the milk. The milk tests were the same as at the collection centre.

Figure 13: Loading the tanker truck with cooled milk to transport it to the processing plant.

Milk intake and milk rejected

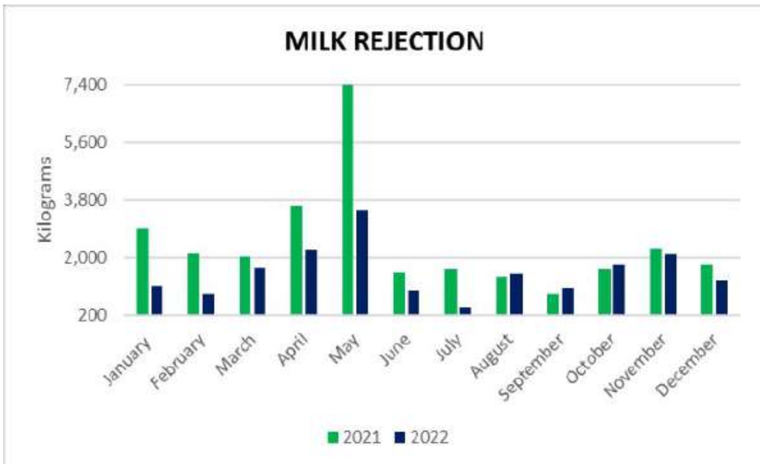
In 2021, Fresha collected 85.1 million kg milk from dairy farmers who are members of the cooperative, while in 2022, the number of kg of milk collected raised to 87.6 million. This was equivalent to 233,000 respectively 240,000 kg milk per day (Figure 14 shows the monthly intake).

Figure 14: Fresha's milk intake in 2021 and 2022. Source: (Fresha, 2022).



The total milk rejection includes the rejection during collection of the milk as well as after transport to the cooling center or processing plant. Milk rejection in 2022 was lower than in 2021, on average 1,559 kg and 2,439 kg per month respectively (Figure 15). Main differences in 2021 compared to 2022 are shown in January, February, April, May, and July. On average, the milk rejections of the total milk intake were 0.034% and 0.021% respectively, comparable to data of Katarama (2022).

Figure 15: Fresha's monthly milk rejection in 2021 and 2022. Source: (Fresha, 2022).



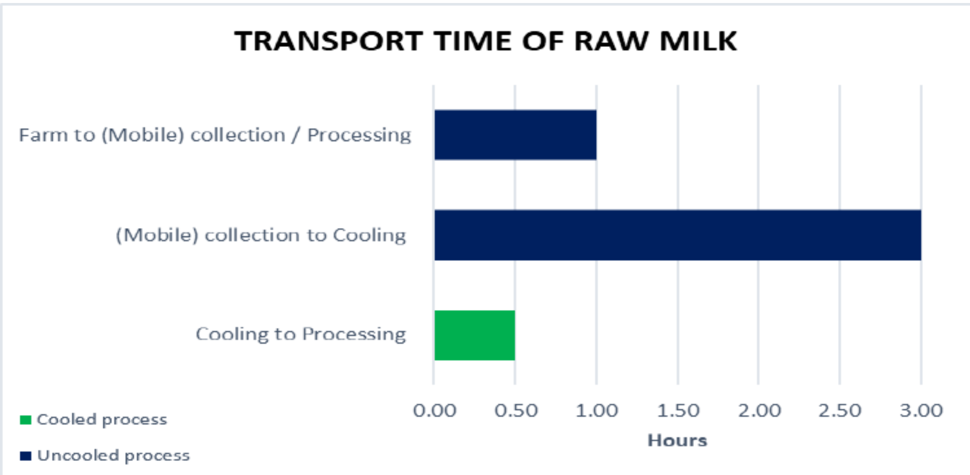
Reasons for the high amount of milk being rejected were the drought period and fodder insecurity, which influenced the milk quality. Furthermore, the hygiene of Fresha's milk cans, the duration of transport, the temperature of milk at collection and the subsequent temperature rise during transport to the processing plant could be possible causes (Table 1).

Table 1: Main reasons of milk rejection Fresha.

MILK REJECTS	REASON OF REJECTION	POSSIBLE CAUSE OF REJECTION
During milk collection	Alcohol positive	Hygiene (cows/stable/milk can farmer) Mastitis Late or extended lactation
	Off smell / Acidity	Hygiene, storage temperature, duration of transport to collection center
	Density <27 L.R or >32 L.R	Treated milk: water or neutralizers added
After transport at the milk entry to the cooling center or processing plant.	Alcohol positive	Test not executed properly during milk collection
	Off smell / Acidity	Cleaning, draining, and drying of Fresha's milk cans, duration of time that milk is not cooled to 4°C, milk temperature at collection that exceeds the maximum acceptable of 6°C

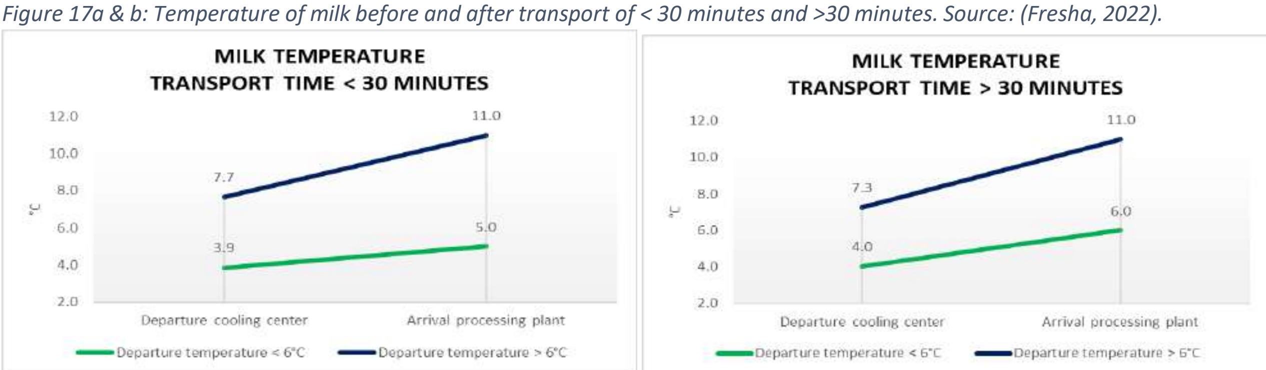
The quality of milk is affected by the time it is transported and the temperature to which it is cooled. To avoid losses, it is important to cool fresh milk to <6°C within two hours of milking and to 4°C within a maximum of three to four hours. In the short supply chain, transport of uncooled milk from the farm to collection centre and then processing plant took a maximum of 1 hour. In the long milk supply chain, transporting raw milk took a maximum of 4 hours before being cooled. Finally, the milk from the cooling center to the milk processing plant was transported in half an hour on average (Figure 16).

Figure 16: Transport time of Fresha's raw milk per stage in the supply chain, from farm to processing plant. Source: (Fresha, 2022).



Temperature differences of milk at the cooling centres between shorter or longer than 30 minutes showed no significant difference (Figure 17a & b).

Figure 17a & b: Temperature of milk before and after transport of < 30 minutes and >30 minutes. Source: (Fresha, 2022).



Cleaning and drying the milk cans

All the raw milk produced by the Cooperative members was transported in aluminum milk cans. At collection, the farmers delivered their milk and empty their milk cans in the Fresha owned milk cans, after which the farmers went home and cleaned their milk cans themselves After the Fresha owned milk cans were emptied, the milk cans at the cooling centres and processing plant were cleaned with the following procedure. After emptying the milk can, milk residue was removed by rinsing the can with chilly water. Then the inside of the can was washed with hot water and a chlorine-based sanitizer. After that, the can was rinsed again with chilly water to remove soap residue. Finally, the milk cans were disinfected with sodium bicarbonate, and drained and air-dried in an inverted position in a rack (Figure 18).

Figure 18: Washing and drying Fresha's milk cans. Source: (L. van den Broek, 2022).

Figure 19: Milk cans with residual water and not dried in an inverted position. Source: (L. van den Broek, 2022).

At the collection points, the procedure was different. Milk cans were not air-dried in an inverted position, while a rack was available for that purpose. Milk cans with residual water was regularly observed (Figure 19). When this is not applied, the remaining water mixes with milk at the next collection moment. This can negatively affect the quality of the milk after collection.

Transport costs

In total, Fresha owned six trucks carrying milk cans and six milk tanker trucks of 10-11 tons of milk. Besides, 30 transporters were hired to transport the raw milk in the milk cans. This system of outsourcing milk transport made Fresha very flexible related to the milk input fluctuations during the year.

Comparison of Fresha's own data on transport costs showed that, the cost of transporting raw milk in 2022 was KES 2.64 per kilogram of milk per month, of which KES 2.03 originated from own transport means and KES 0.61 per kilogram of milk per month from hired transport. Since the sizes of the trucks and tankers and the number of rides per day are not comparable, no further conclusions can be made.

Conclusions and recommendations

The main opportunities for improvement to increase quality and to ensure efficiency are improving 1) the road infrastructure, 2) the overall time between milking and entry to the factory at which the milk is above 6°C, 3) the temperature of milk before, during and after transport, 4) transition from transporting milk in milk cans to milk tankers, and 5) the position of milk cans when stored to drain and dry.

The improvements can be implemented by engaging the government to improve the road infrastructure, constructing multiple cooling centres, and investing in insulated tankers, for which an investment plan should be developed. In addition, implementing internal policies and training can ensure that milk is cooled to less than 6°C, temperature is measured, recorded, and analysed, and milk cans are stored upside down to drain and dry.

Furthermore, further analysis to reduce transport costs by outsourcing transport of milk cans to hired transporters was encouraged. Maintaining control over the supply chain can be implemented by setting policies, training, and monitoring systems.

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Assessment of Readiness of Adopting Quality-Based Milk Payment System (QBMPS): a case study of Githunguri Dairy Farmers Cooperative Society in Kiambu County-Kenya.

Ilhan Tahlil Guled, Marco Verschuur

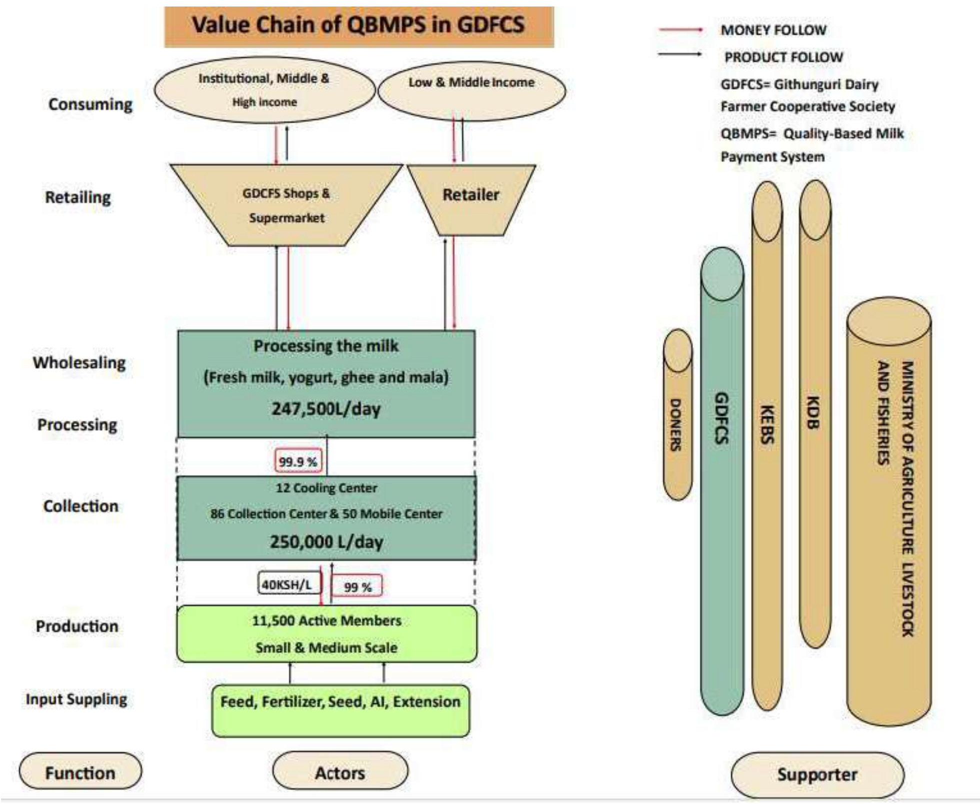
Practice Brief
FORQLAB Project 2023-11

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

The study was conducted in Githunguri Sub-County, Kiambu County, Kenya. The primary objective was to comprehensively assess the cooperative's preparedness of Githunguri Dairy Farmers' Cooperative Society and its members for implementing Quality-Based Milk Payment System (QBMPS) to enhance to milk quality and to reduce food losses. The milk value chain in Githunguri is a well-integrated chain from the initial stage of production to subsequent processing and eventually retailing (Figure 1). The cooperative provided a range of significant services for instance, AI, extension and training, feed store, and consultation in feed and feed formulation, farm hygiene, animal welfare and treatment of mastitis (Baars and Verschuur, 2020; Katarama, 2022). The GDFCS had an interest in shifting from a quantity-based to a quality-based payment system which will lead to standout and be more sustainable in the long run.

Figure 1: GDFCS Value Chain Map

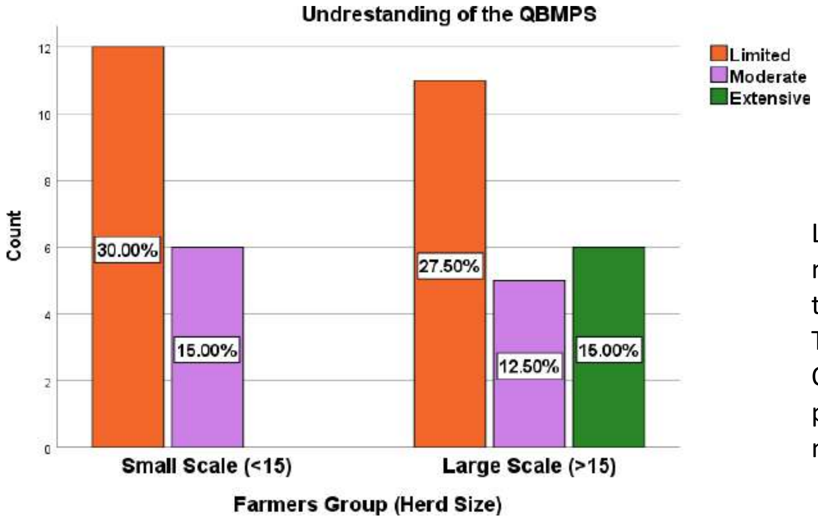


Methodology

Both qualitative and quantitative data were collected for this study. A survey was conducted with 40 farmers, categorized into two clusters based on herd size (small-scale, less than 15 animals, and large-scale, more than 15 animals). Additionally, interviews were carried out with 5 cooperative staff and 5 key informants representing various stages of the dairy sector. Furthermore, a focus group discussion (FGD) was organized with 10 farmers, specifically addressing the costs and benefits associated with the adoption of QBMPS. To analyze survey data, a statistical approach was employed. Statistical tests such as the independent T-test were used to compare farmers from both clusters, utilizing SPSS version 26. For qualitative data analysis, the Notta app provided crucial support. The gathered data was meticulously coded, transcribed, and interpreted to derive meaningful insights. For the readiness level, 7 parameters were assessed: the cold chain status, milk test and quality level, record keeping, understanding and willingness of the QBMPS, costs and benefits of the QBMPS, as shown in the spiderweb below (Figure 8).

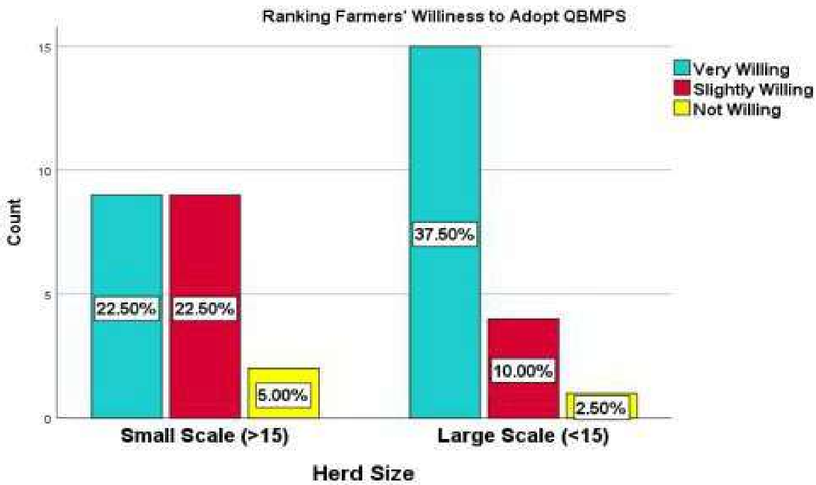
Farmer perception on QBMPS

Figure 2: Farmers Understanding of the QBMPS. N=40



Large scale farmers tended to have more understanding about QBMPS than smallholders (Figure 2).
The willingness to shift towards a QBMPS was accordingly, while a small percentage (7.5%) did not want to make that shift (Figure 3).

Figure 3: Willingness to Adopt QBMPS. N=40



Quality parameters

A remarkable foundation of the GDFCS value chain are the quality parameters which stands as safeguarding measure to ensure the safety of the fresh milk and dairy products as well.
They adhered to a rigorous set of quality parameters that were precisely tested on the milk collected from its members. These tests were conducted at three different levels. Firstly, some tests take place at the collection centres, where farmers initially bring their milk. Secondly, at the cooling centres, where the milk is bulked and cooled before further processing. Finally, the most critical examination is carried out at the main processing plant, where the milk undergoes various stages of production to become final dairy products (Table 1). When specific quality parameters fall under the standard, the concerned milk was promptly rejected, reflecting GDFCS' unwavering dedication to maintaining elevated quality standards. Furthermore, other quality violation e.g., incidence of adulteration resulted in rejection and penalty. This strategy promotes an accountability culture and supports the excellence criteria that characterize the Githunguri dairy value chain.

Table 1 Tests carry out at farm level, collection, cooling, and plant centres.

Tests	Where	How	Normal Range
Organoleptic	All	Individual	Clear-Normal
Alcohol	Collection Center	Individual	Negative
Density at 200C	Collection Center	Individual	1.27-1.34
Mastitis	Farm Level	Individual	Negative
Ph	Processing plant	Bulking	6.6-6.8
Aflatoxin	All	Individual, Bulking	<0.5ppb
Neutralizer	All	Individual, Bulking	
Resazurin	Cooling Center & Processing Plant	Bulking	Blue, Light Blue & Purple
Fat	Processing Plant	Bulking	Min 3.25 %
SNF	Processing Plant	Bulking	Min 8.5 %
Protein	Processing Plant	Bulking	Min 3.2 %
Total plate count	Processing Plant	Bulking	Max 2,000,000 cfu/ml
Antibiotic residue	All	Bulking	Not more than 10ppb
Somatic Cell Count	Processing Plant	Bulking	Max 300,000
Bacterial Load	Processing Plant	Bulking	
Coliform			Max 50,000 cfu/ml

Source: adopted and expanded from Katarama (2022)

Milk rejection

Most farmers (47.5%) identified mastitis as the main reason for milk rejection by the cooperative. Subsequently, 22.5% of the farmers indicated the use of antibiotic due to mastitis, followed by aflatoxin and alcohol positive for 7.5% each (Figure 4). Most dairy farmers (60%) replied that they fed the rejected milk to other animals (calf, dog and pig), while 22.5% sold it aside to extract some income and 17.5% discarded the rejected milk (Figure 5).

Figure 4: Reasons of Milk Rejection

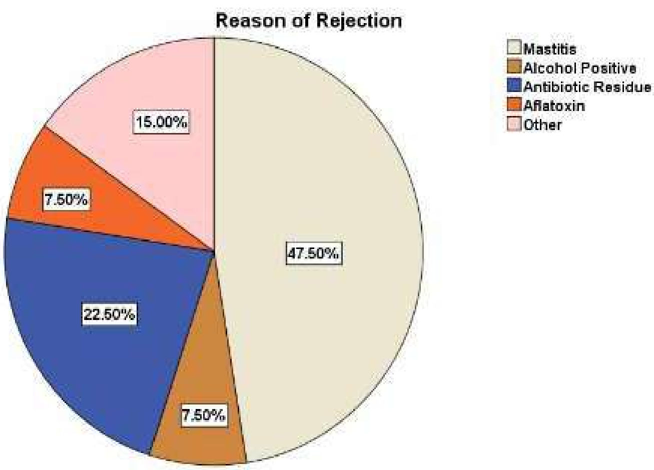
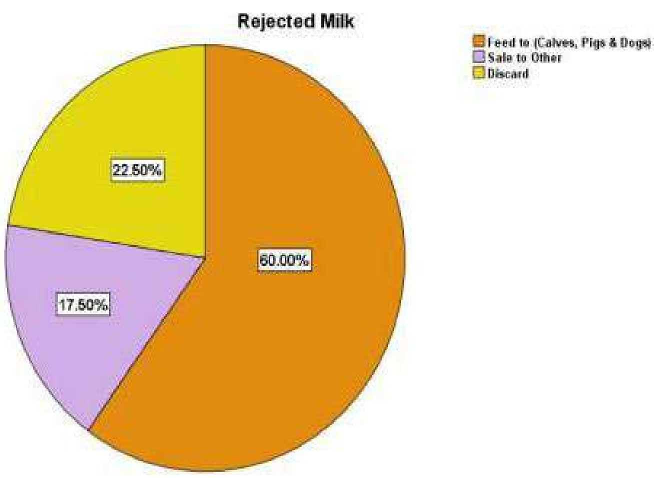


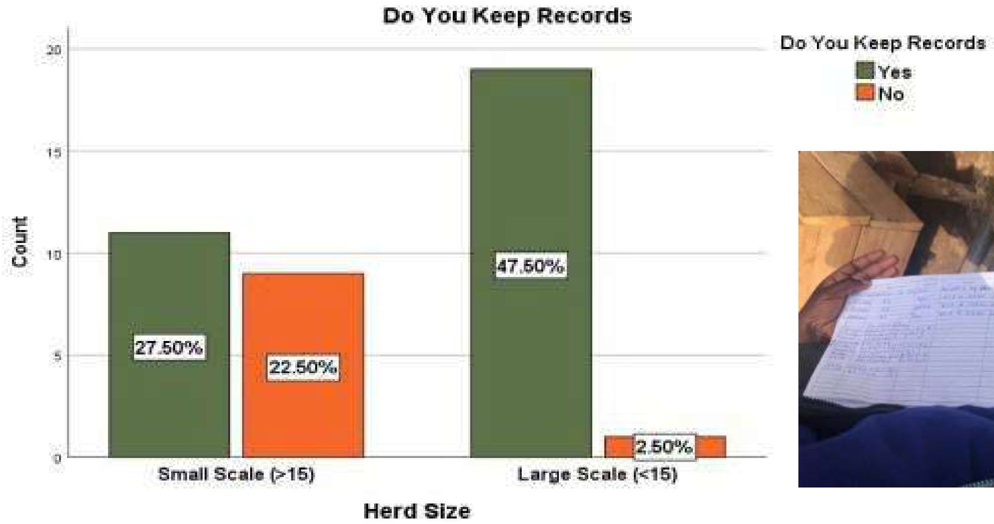
Figure 5: Use of Rejected Milk

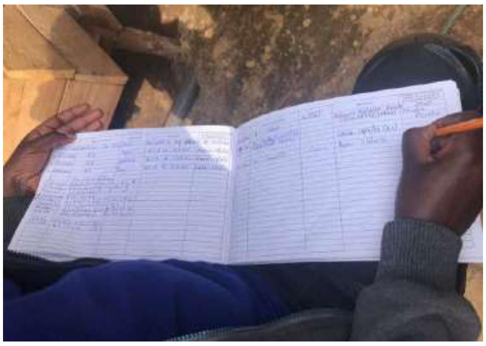


Record Keeping

The survey findings showed that 74% of the farmers confirmed that they keep records (Figure 6). Most of the large-scale farmers (19 out of 20) indicated that they constantly maintain farm records. According to an extension officer, farmers in Githunguri received training on appropriate record-keeping techniques.

Figure 6: Record Keeping



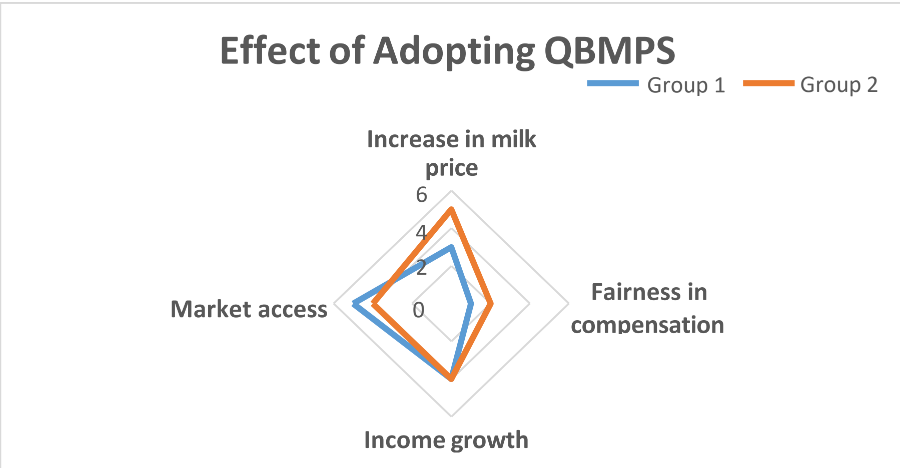


Effects of adoption of QBMPS

In a FGD, farmers elaborated criteria with benefits and costs of QBMPS (Tables 2 and 3).

To assess the effect of adopting of a QBMPS on farmers' income, 4 qualitative criteria were used: increase in market access, milk price, fairness in compensation and income growth. This was presented in a spiderweb for the two clusters (Figure 7).

Figure 7: Effect of Adopting QBMPS According to Farmers' Perspective. Gr. 1 smallholder, gr. 2 large scale farmers



Group 1 (smallholders) showed notable propensity, with highest score leaned toward market access. In contrast, group 2 (large scale farmers) their highest score attributable to the measurement of an increase in milk price. Both groups registered the lowest score for the fairness of compensation within the quality-based payment, which suggests some doubt against the idea that the proposed QBMPS compensation strategy will fairly and appropriately compensate their sincere efforts.

Figure 8: graders scaling the received milk

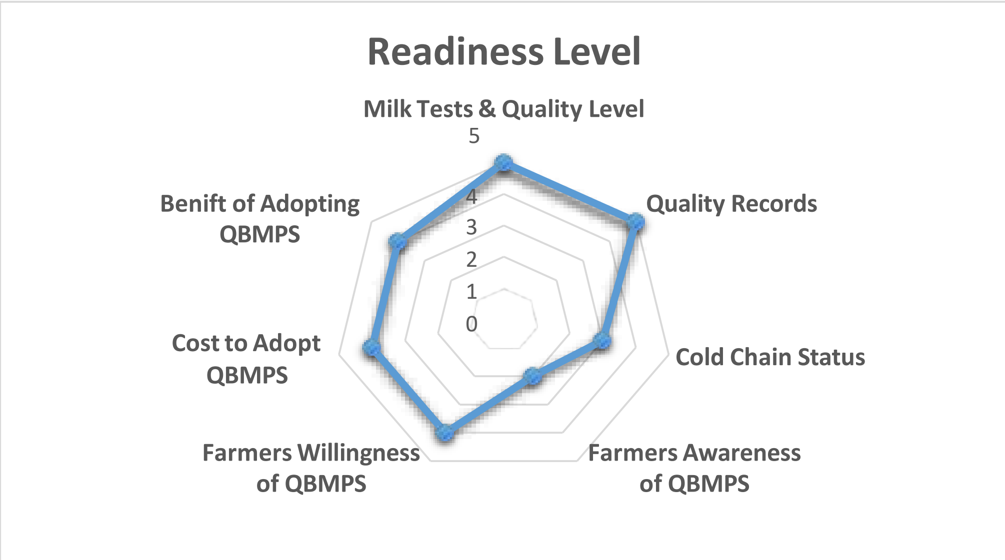
The graders (Figure 8) and quality assurance of the cooperative highlighted the quantity of milk supplied by the farmers, the cost of the test and the demand to hire extra staff as major challenges in the implementation of a QBMPS. According to the milk inspectors, due to the low volume of the milk supplied by small-scale farmers, carrying out the tests separately will be time-consuming and consequently predispose to milk spoilage. Some tests that currently are done after bulking will require to be done individually which increases the operational cost of the cooperative society.

According to GDFCS staff: “Although the implementation of QBMPS will have a high cost, it will provide an enormous benefit to the cooperative by reducing the cost of supplement product that is used during yoghurt production and providing the possibility to extract an extra amount of fat from the milk”. According to the KALRO-expert, the milk quality in Githunguri was not the main problem, but the small farm sizes that affects feed production, herd size and the demand of farmers to purchase feed from other counties.

Readiness level

A readiness level ranking matrix was developed to assess the level of preparedness of the cooperative to implement QBMPS (Figure 8). The ranking matrix was filled by five cooperative staff members. The milk testing and the presence of quality records were given the highest preparedness level. The feasibility of costs and benefits of QBMPS and farmers' willingness to engage were ranked as the second. Farmers' willingness was also high as it was supported by the outcome of the questionnaire. However, the status of the cold chain and farmers' awareness were marked 3 and 2 respectively. Concerning the cold chain, it was reported that not all milk trucks were refrigerated, possibly jeopardizing the milk quality in the chain. In addition, the awareness of farmers about the QBMPS was low as illustrated by the survey.

Figure 8: Ranking GDFCS Readiness Level to Adopt QBMPS



Conclusion

The implementation of a Quality-Based Milk Payment System (QBMPS) has both benefits and challenges. GDFCS placed a strong emphasis on ensuring safe and high-quality dairy products through the adoption of several quality parameters such as organoleptic, alcohol, density, fat and protein, antibiotic residue, aflatoxin, SCC, TBC, TPC. Enhancing milk quality, fair compensation for farmers, market competitiveness through the offer of premium products, sustainability, and member engagement were the main drivers of the cooperative to adopt QBMPS. Large-scale farmers indicated a higher understanding of QBMPS than the small-scale farmers. Despite the reported limited awareness and knowledge, both groups showed interest to adopt QBMPS after giving an overview of the system. The study highlights the promising impact of QBMPS on milk quality, farmer income, and livelihoods, as well as the challenges in implementation costs, resistance, and concerns regarding the fairness of the system. The cooperative's ability to diversify products and enter new markets through QBMPS implementation is highlighted.

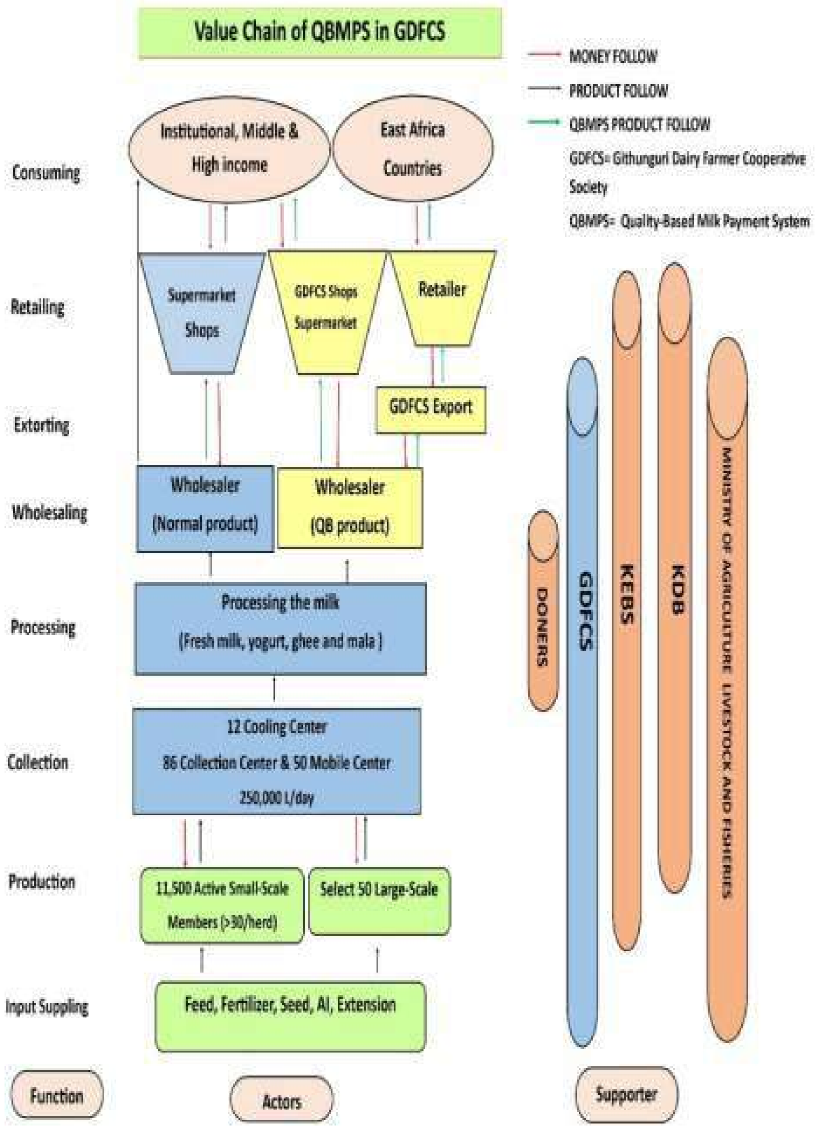
The study suggested strategies to overcome operational and financial hurdles and emphasizes the importance of targeted educational initiatives to enhance farmer understanding and participation for improved milk quality and economic benefits. The assessment of readiness levels highlights areas for enhancement, including cold chain infrastructure and sustainability practices, underlining the need for continuous improvements in various aspects for successful QBMPS integration.

Furthermore, to try the effective implementation of QBMPS, a pilot study was suggested for 50 selected large-scale farmers, based on positive experiences in Uganda (Daburon and Ndambi, 2019). Also, a new milk quality payment structure (Table 4) and new chain (Figure 8) are recommended.

Table 4: Proposed Milk Quality Parameters and Payment Structure

	Quality Parameters						Payment Structure	
	Fat %	**Protein %**	**TBC**	**SCC**	**Antibiotic (-)**	**No Adulteration**	**Payment**	**Amounts**
Grade A$^+$	4	>3,6	<200,000	<200,000	Negative	Negative	Premium	+2
Grade A	3.5-3.8	3.6-3.3	1-200,000	<300,000	Max 10 ppb	Negative	Standard	Standard
Grade B	3.25-3.5	<3.2	≤200,000	>300,000	> 10 ppb	positive	Deduction	-
Grade C	< 3.25	<3	<200,000	>300,000	> 15 ppb	Positive	Rejection (No Payment)	-

Figure 8: New Value chain after implementation of QBMPS



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Farmer exchange to Githunguri DFCS Report
12-15th December 2023

Introduction

In the period from December 12 to 15, 2023, a group of six farmers from Kitinda and Kaptama cooperative societies engaged in an insightful exchange with Githunguri/Fresha Farmers' Cooperative Society (GDFCS). The primary objective of this exchange was to foster collaborative learning, facilitating the sharing of experiences and an in-depth reflection on both successes and lessons from these interactions and formulate a comprehensive Back Home Action Plan (BHAP) for subsequent implementation to improve respective cooperatives. Structured around farm, collection, and cooling center visits, the exchange also encompassed individual and group reflections, as well as key respondent sessions. This report presents a summary of key highlights of the exchange, focusing on Githunguri's strategies to mitigate milk waste and losses at each stage and further discussions on their perspectives regarding food quality and food losses. The framework of FORQLAB, grounded in the principle of 'Knowledge into action,' guided the exchange, with the overarching goal of leveraging the acquired knowledge, experiences, and skills to enhance the functioning of the participating cooperatives.

Participants in the exchange analyzed key challenges within their cooperatives, particularly concerning production (farm level) and milk waste, loss, and quality. The culmination of this collaborative effort was the development of individual Back Home Action Plans, which stood as central pillars of the exchange process. These action plans are more than just documents; they represent a commitment to turning the lessons learned during the exchange into real, tangible improvements within each cooperative. The follow up of the BHAP implementation was agreed to take place in Mid-March, 2024.

Box 1: Overview of Githunguri Dairy Farmers cooperative society

- 27,607members, primarily small-scale dairy farmers, but only 11,500 are active.
- 86 collection centres, 163 mobile collection points; 11 cooling centres.
- The catchment area is about 20 square kilometers, divided into ten administrative regions.
- 265,000 litres of milk collected every day
- Currently, Githunguri purchases milk from farmers based on volume, with a fixed price of Ksh49 per litre.

1. Day 1: Model Farms Visits (2)

The visit provided an exposure to two distinct types of farms in Githunguri, each with varying levels of goal, intensity, and efficiency. This was planned to offer participants with diverse perspectives on crucial aspects such as scale, investment, and farm objectives within the realm of commercial dairy farming- facilitating a comprehensive understanding of the intricacies of commercial dairy farming. The participants had the experiences of two full-time farmers, who shared the histories of their farms, highlighting their journey from modest beginnings to gradual herd expansions over the years, with a commitment to breed improvement, resulting in the status of having pedigree animals and continuous improvement of their farms.

The key drivers behind the success of both farms were identified as an unwavering commitment to passion, discipline, consistency, and investment. These core values played a pivotal role in shaping the farms into models of efficiency, providing valuable insights into the evolution of their practices and the strategic decisions that led to their success. The participants engaged in discussions aimed at identifying areas of improvement within their own Back Home Action Plans (BHAP). These deliberations were further enriched by a video presentation by Jo Anne Voort and Tom van Melick from Aeres University of Applied Sciences (https://youtu.be/X6qbnH8lHUU), which served as an integral component of the agenda, contributing significantly to the formulation of improvement plans.

2. Day 2: How Githunguri handles quality and losses: Visits to Collection and Cooling centres

2.1 Milk transportation

The cooperative logistics plan involves 12 owned trucks, complemented by an additional fleet of 30 hired trucks. The cooperative's choice to rely more on hired trucks is a result of careful evaluation of economic factors, considering the overall costs associated with owned trucks, such as driver salaries, fuel expenses, and maintenance costs. By choosing hired transport, the cooperative strategically lessens the financial burden tied to owning and running a large fleet. This decision allows for a more efficient allocation of resources, improving operational efficiency and ensures that financial resources is directed to other crucial aspects of the cooperative's initiatives. This logistical strategy in Githunguri aligns well with the operational approach in Kaptama, highlighting a trend in cooperative practices. This shared reliance on hired transport by Githunguri and Kaptama indicates a cooperative mindset that prioritizes optimizing transportation resources, fostering a more sustainable and cost-effective model as recommended by Linda vd Broek from HAS https://youtu.be/X6qbnH8IHUU. Truck breakdowns during milk transportation are few, and the responsibility lies with the transporters to promptly dispatch a rescue truck. Transporters are held accountable for any spoilage-related losses incurred. From the cooling point to processing plant, the milk is collected by using GDFCS tankers installed with milk tanks. Except for long routes, milk collected from short routes are transported direct to the processing plant.

2.2 Milk collection and cooling

The cooperative manages 11 cooling centers, strategically prioritizing a short supply chain to uphold milk quality. Standardizing milk delivery with the exclusive use of aluminum cans ensures consistency in the process. Collection procedures are meticulous, involving rigorous tests conducted by graders before purchase, including a lactometer test, an alcohol test, and an Organoleptic test. Milk losses at the collection center primarily result from rejection due to poor-quality milk delivered and during the exchange, rejection of delivered milk was noted in the collection centers visited. To address this, the cooperative follows up with farmers whose milk has been rejected through inspectors and extensionists, penalizing or suspending those with repeated rejections.

Despite the cooperative having implemented strategies like observing good milk handling practices and utilizing security seals on cans for traceability, occasional spillage during milk transportation from collection centers to the cooling point was observed. To address this, the cooperative is proactively ensuring proper sealing of milking cans, with heightened attention recommended during both loading and off-loading processes. Instances of spoilage from delayed transportation are rare, emphasizing the crucial role of contracts with transporters to guarantee secure and timely milk delivery.

The milk purchasing process is digitally recorded, with each farmer having a card containing their details. The gadget automatically retrieves farmer details from the card, matches it with the milk on the weighing scale, and sends the milk amount to the farmer via SMS. One student from Egerton University, Maurice Simiyu is ongoing with his research thesis in Githunguri on effect of digital technologies in reducing dairy postharvest losses, under the FORQLAB project. This will give more insights on how these technologies can be used to reduce milk waste and losses.

Milk collection cans are promptly transported from collection centers to cooling centers for chilling to 6 degrees before tankers then collect the chilled milk for delivery to the processing plant. Upon arrival at the cooling center, repeated tests are conducted to maintain stringent quality standards. Reports of adulterations and neutralizer additions in Githunguri have prompted tests at the cooling plant, and random aflatoxin tests to contribute to comprehensive quality control measures in the milk processing system. Although various parameters are tested, some, such as protein, fat, and aflatoxin levels, were not given significant attention at collection centers, and milk are not rejected based on these parameters.

Summary of Milk Parameters tested at different levels.

Parameter	**Testing centre**	**Specification**
Milk fat	All milk collection and cooling centres	3.5%
Milk protein	All milk collection and cooling centres	3.2%
Freezing point	All milk collection and cooling centres	-0.550 to -0.525°C
Alcohol test	All milk collection and cooling centres	Negative
Clot-on-boiling	All milk collection and cooling centres	Negative
pH	All milk collection and cooling centres	6.6 TO 6.8
Density at 200C	All milk collection and cooling centres	1.028 TO 1.034g/ml
Milk SNF	Cooling point, Processing plant	Min8.5%
Antibiotic residue	Cooling point, Processing plant	Not more than 10ppb
Aflatoxin M1	Cooling point, Processing plant	Less or equal to 0.5ppb
Total plate count	Processing plant	max 2,000,000cfu/ml
Coliform	Processing plant	Max 50,000cfu/ml
Somatic cell count(SCC)	Cooling point, Processing plant	Mx 300,000

3. **Back Home Action Plans**
   3.1 Kaptama Dairy Farmers Cooperative Society

Problems identified for our dairy to be tackle after bench marking are:

- Poor Breeds of animals
- Poor Animal feed management
- Ownership of dairy animals
- Poor policy between members and cooperative
- Poor records of animals at farm level
- Lack of collection centers structure
- Use of Plastic containers
- Lack Automation of farmers records
- Inadequate quality milk controls
- Milk spillage
- Lack of Footbath
- Lack of Animal feeds and its store
- Lack of Cooperative farmers shop
- Lack of digital weighing scale at collection centers the cooperative use liter cup

The following are related challenges

a) Use of communal bull
b) Believe that Zero-grazing animals doesn't produce more milk like those that graze outside.
c) Farmers are not determined in delivering milk on time.
d) Expensive artificial insemination (A.I)
e) Poor market of milk that offers less price to farmers
f) Because high cost of buying metallic aluminum cans

Environment

a) Most farmers don't have zero grazing units or shades hence they feed their animals deep in the forest hence low production of milk due to distance and animals that finds feeding in forest are prone to theft.
b) Climatical changes especially during rainy season whereby dairy cows are prone to pests and diseases hence there's delay in milk delivery at the cooling center due to heavy rains.

Technical

In adequate extension and quality assurance officers due to financial constrains to employ them.

What makes the problem hard?

a) Attitude

b) Insufficient capital both for the cooperative and farmers to implement proper dairy farming methods and automation of systems in the cooperative among other factors
c) Inadequate information on feeding and housing
d) Policy implementation on plastic containers and time of collecting milk at collection Centers.

The Stakeholders within the area of the case

a) Members of the cooperative
b) National Government and County Government this includes the following:
    - ✓ Administration
    - ✓ Sub-County cooperative officers
    - ✓ Veterinary officers
    - ✓ Breeding organizations like Kenya Animal Genetic Research Center (KAGRC) and Agricultural Development Corporation (ADC)
c) Micro finances to aid Farmers access loans for example Eclof Kenya, skyline Sacco, Kaptama Rural Sacco, cooperative bank.

Involvement of the board expertise, roles, and responsibility after the exchange

NAME	**DESIGNATION**	**ROLE TO TAKE UP BACK HOME**
TOM KIPNESTY NDIWA	CHAIRPERSON	a) Linking with other Board members and give a comprehensive report of the tour to Githunguri Dairy b) Zonal meetings with Farmers through Board members c) Invite professional to advice farmers on feeding, breeding, and animal housing. d) Linking farmers with Micro Finances e) Policy making by board members on plastic and disciplinary action from board members. f) Coming up with a five-year strategic plan
ALEX KIPSANG NAIBEI	SECRETARY	a) Proper Recording and documentation of polices. b) Update members through bulk messaging of programs offered by the cooperative i.e. silage making, loans etc c) Make schedules for meetings. d) Make reminders. e) Proper records of membership
MARK NGEYWO MAKET	MANAGER	a) Perform accounting duties including Budgeting and cost controls. b) Accounting and bookkeeping for the society. c) Keep proper records of farmers and equipping farmers on finances aspect of their accounts and check offs in case of those taking loans d) Policy implementations e) Tracking of strategic plan

3.2 Kitinda Dairy Farmers Cooperative Society

Problems identified for our dairy to be tackle after bench marking are

- Lack of intensive dairy farming practices
- Feeds and feeding issues.
- Poor breeds
- Poor farm records
- Use of plastic containers
- No structures/ milk collection centers not organized
- Long time taken from farm to chilling plant
- Lack of extension services
- Absence of milk testing

The following are related challenges

Social

a. Minimal women involvement
b. Poor attitude

Financial

c. Farmer financial illiteracy

Environment

Technical

d. inadequate extension and quality assurance officers due to financial constrains to employ them.

What makes the problem hard?

e. Technical and financial capacity
f. There is no common platform for stakeholders to co-create solutions.

The Stakeholders within the area of the case

d) Linear ministries
e) GIZ, KDB, BAS, MSEA, Bungoma Alumni, CBOs

Involvement of the board expertise, roles and responsibility

NAME	DESIGNATION	ROLES RESPONSIBILITIES
Cyprian Wekullo	CHAIRPERSON	g) Advocacy, technical and resource mobilization h) Formulation of policies to govern milk handling
Prisca Mayende	Treasurer	f) Training farmers on new knowledge and skills from Githunguri
Bonaventure Masibo	Manager	f) Implement good dairy management systems g) Implement cooperative policies for members and workers

Integrated Assessment of the Presence and Levels of Contaminants (Aflatoxins, Antibiotics and Acaricides) in Raw Milk in the North Rift Region- Kenya

Bethel Odera Pendo, Robert Baars, Marco Verschuur

Practice Brief
FORQLAB Project 2024-01

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

Kenya is one of the prominent milk producers in Sub-Saharan Africa, with a dairy sector that contributes a substantial 4-8% to the Gross Domestic Product (Creemers and Aranguiz, 2019). This sector is an economic driver, providing income and employment to over 1.0 million households across the dairy value chain (Creemers and Aranguiz, 2019). The annual average per capita milk consumption is high, equivalent to 115 litres (International Livestock Research Institute, 2023).

Currently, 80% of the milk in Kenya is produced by smallholder farmers (Creemers and Aranguiz, 2019) and sold in the informal market, which makes up about 80% of all milk sales in the country. The informal dairy market typically lacks infrastructure and reliable access to clean water, electricity, sanitation, and refrigeration facilities and does not follow safety regulations. Additionally, it operates without a license, receives little support from the government, and is excluded from the formal market. Most milk in this market is sold raw (unpasteurized) and unpackaged. This sector depends on the spot market. In contrast, the formal market is managed by licensed dairy enterprises that operate within a clear legal framework, have established facilities, and undergo regular inspections. Key participants in this market include processing companies and cooperatives such as Brookside Dairy Limited, Kenya Co-operative Creameries LTD, Githunguri Dairy Farmers Cooperative Society, and Bio Foods Products Ltd, among other processors.

The high share of milk commercialized through informal channels poses a challenge to quality control and minimizing losses in the Kenyan dairy sector (Blackmore et al., 2021). Various contaminants seriously threaten milk's safety and quality.

Bio Foods Products Ltd. (Bio Foods), a privately-owned milk processing company recognized for producing high-quality dairy products, is experiencing a high demand for its premium products. However, the company is currently dealing with the problem of inconsistent supply of high milk volumes due to milk contamination. There is an opportunity to source milk from the informal market. However, the company must ensure that this milk meets its quality requirements and is free from contaminants (antibiotics, aflatoxins and acaricides). The challenge at hand is the lack of effective strategies to keep these three contaminants below threshold levels to enable Bio Foods to channel this milk into their supply chain.

Study Objective

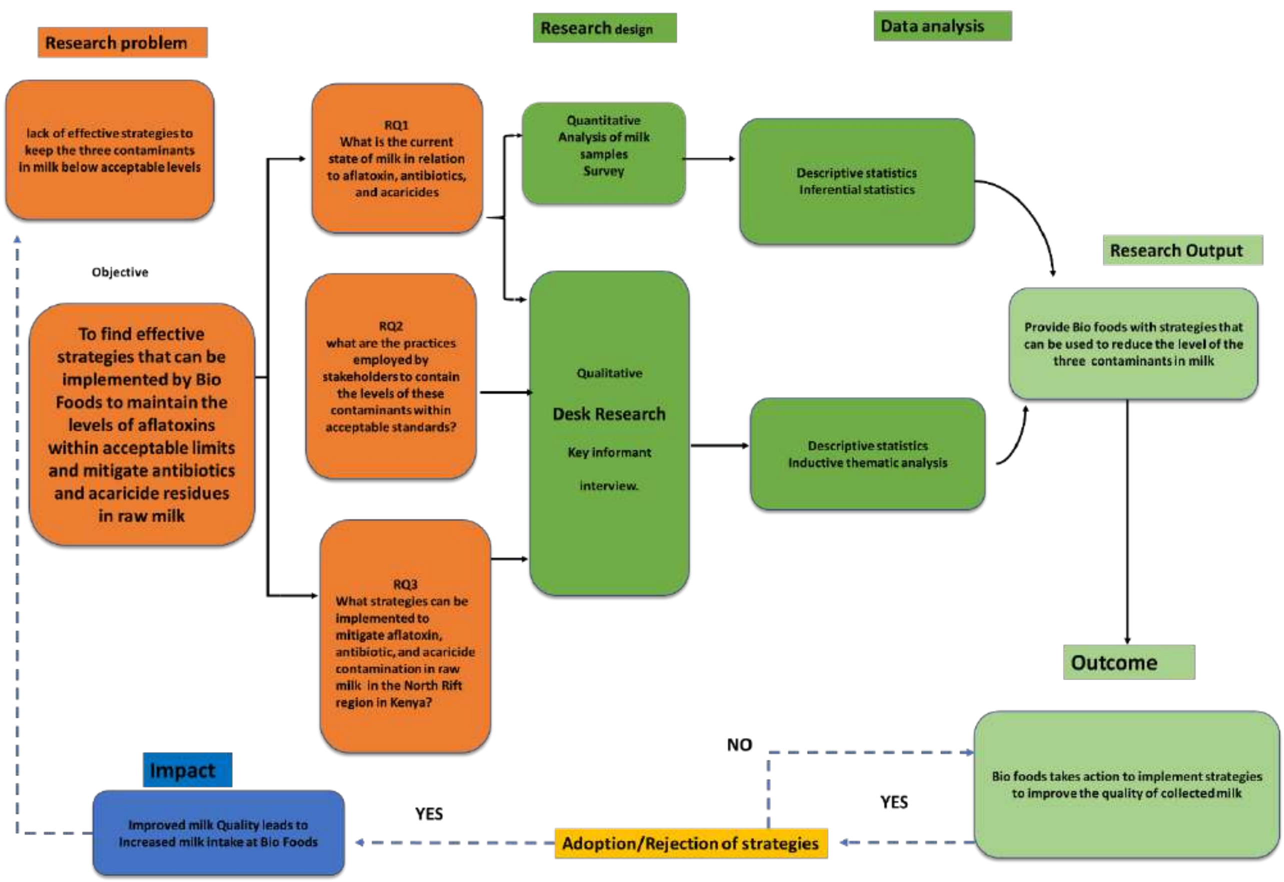
The overall objective of this study was to find effective strategies that Bio Foods can implement to maintain the levels of aflatoxins within acceptable limits, mitigate antibiotics and acaricide residues in raw milk, and enable them to uptake milk from the informal market**.** The research was done by carrying out a comparative analysis of the milk quality from the current Bio Foods suppliers and non-Bio Foods suppliers, different practices carried out by the two groups in relation to contaminants and suggested recommendations to the non-Bio Foods suppliers to ensure their milk conforms and onboard with Bio Foods.

This study was conducted in the North Rift region, in Uasin-Gishu, Trans-Nzoia and Baringo counties. These areas were chosen because most Bio Foods farmers were concentrated in these areas, and the area was a major milk catchment, therefore considered a potential source of milk for Bio Foods.
A mixed approach of qualitative and quantitative techniques was used. Survey, chemical analysis of milk samples and analysis of feed samples were done for the quantitative aspects. Key informants from Bio Foods, cooperatives and Kenya Dairy Board were interviewed for the qualitative part. Comparative analysis was then done for the Bio Foods suppliers and non-Bio Foods suppliers from the informal channels.
Purposive sampling was used to select farmers and key informants. A total of 16 farms were selected to participate in the survey, eight Bio Foods suppliers and eight non-Bio Foods suppliers.

Conceptual Framework

The study was modelled on a conceptual framework of a theory of change (Figure 1). Originating from the research problem and focusing on the outcome of the study where, Bio Foods would be provided with strategies to manage the three contaminants.

Figure 1. Conceptual framework used for the study. RQ=research question.



MAIN FINDINGS

Table 1. Levels of contaminants in milk of Bio Foods farmers and non-Bio Foods farmers. ppt=parts per trillion; µg=microgram per kg; ppb=parts per billion.

Contaminants	Bio Food suppliers (N=8)	non-Bio Food suppliers (N=8)	Average	Bio Food supplying coop (N=1)	non-Bio Foods Supplying coop (N=2)	Average
Aflatoxins in milk (ppt)	116.5[a]±102.4	326[b]±224	221±163.2	360	164±92.9	262±46.5
Acaricide (Cypermethrin µg/kg)	85.6±50.4	104.7±43.1	95.2±43.5	34.8	83.0±46.4	58.9±23.2
Acaricide (Organophosphate µg/kg)	14.7[a]±27.2	0.0[b]	7.3±13.6	42.2	62.1±36	52.2±18
Antibiotics	0.0[a]±0	1.4[b]±0.7	0.7±0.4	0	0	0
Aflatoxins in feeds (ppb)	2.8±2.8	4.3±3.4	3.6±3.1	0.0	0.3	0

AFLATOXIN

A t-test analysis revealed a significant difference in the average aflatoxin levels between milk samples from Bio Foods and non-Bio Foods farmers ($p<0.05$). This indicated that Bio Foods farmers had distinct lower aflatoxin levels with a mean average of 116 ppt compared to non-Bio Foods farmers with a higher mean of 326 ppt. However, the aflatoxin level in Bio Foods supplying cooperatives was high at 360 ppt compared to the non-Bio Foods supplying cooperatives, averaging at 164 ppt.

The primary source of aflatoxin was confirmed to be feeds. The results revealed that 13 out of 19 samples had aflatoxin B1. A t-test ($p>0.05$) indicated no significant difference between the levels of aflatoxin B1 in the Bio Foods-supplying farms and those from non-Bio Foods-supplying farms. However, it was noted that some farm practices led to the contamination of the feeds at the farm level. Table 2 shows different practices by Bio Foods and non-Bio Foods farmers.

Table 2. Practices of Bio Foods and non-Bio Foods suppliers in relation to aflatoxin.

Bio Foods farmers	**non-Bio Foods farmers**
• Outsource feeds from reputable suppliers & request certificate of analysis • Observe trends of aflatoxin in milk • Store feeds in leakproof stores on pallets • Harvest maize at the right stage and ensile properly	• Outsource feeds or feed ingredients depending on availability & proximity to the farm • Feed in stores, sometimes on pallets or floor • Harvest maize at the right stage and ensiled properly • No certificate of analysis during feed procurement

ANTIBIOTICS

The t-test results showed a significant difference in antibiotic residues between milk samples from Bio Foods and non-Bio Foods farmers ($p<0.05$) (Table 1). All the antibiotic-positive samples were from the non-Bio Foods supplying farms. No milk from both cooperatives tested positive for antibiotics. Antibiotics were confirmed to come from the treatment of cows and failure to withdraw milk from the treated cows. Table 3 summarises the practices of both groups in relation to antibiotic residues.

Table 3. Practices of Bio Foods and non-Bio Foods suppliers in relation to antibiotics.

Bio Foods farmers	non-Bio Foods farmers
• Treatment done by either resident or outsourced vets • Records kept & used for withdrawals • Treated cows milked differently • Distinct visual colours used on treated cows • Board on the parlour with names of treated cows	• Treatment done by either a manager, resident or outsourced vets • Treatment records kept but for culling purposes • Treated cows milked last

ACARICIDES

All the samples collected and tested for cypermethrin were found to be positive. The t-test results showed no significance value ($p>0.05$) between samples from Bio Foods-supplying farms and non-Bio Foods-supplying farms, and both types of cooperatives. The maximum cypermethrin residue limit (MRL) is 50 µg/kg. The results revealed that 84% of the samples had cypermethrin levels exceeding this limit, highlighting widespread use across the tested farms.

Nineteen samples were tested for organophosphates, with 26% testing positive for this acaricide. Notably, all the positive samples exceeded the maximum residue limit of 20 µg/kg. The t-test results showed a significance level ($p<0.05$), indicating a significant difference in organophosphate levels between Bio Foods supplying farms and non-Bio Foods supplying farms. Table 4 shows farmers' practices in relation to both of the acaricides.

Table 4. Practices of Bio Foods and non-Bio Foods suppliers in relation to acaricides.

Bio Foods farmers	non-Bio Foods farmers
• Farmers sprayed/dipped the animals weekly or biweekly using the acaricides • Spraying/dipping was done early to have a difference of 8 hrs. before milking • Farmers made the spraying area far from the milking area • Ensured proper cleaning of the udder before milking • Ensured accurate dosing of the acaricides as instructed • Farmers sampled the deep solution for concentration analysis to avoid overdosing	• Sprayed/dipped the animals weekly or Biweekly using the acaricides • Spraying/dipping was done early to have a difference of 5 hours before milking • Ensured accurate dosing of the acaricides as instructed by the manufacturer • Farmers made the spraying area far from the milking area

Conclusion

The study indicated that milk from both Bio Foods suppliers and non-Bio Foods suppliers was contaminated with aflatoxins, antibiotics, and acaricides. However, the contamination levels of milk from Bio Foods suppliers were significantly lower. This reduction in contamination could be attributed to the effective measures implemented by Bio Foods suppliers to control these contaminants. The presence and levels of contaminants were found to be directly related to farming practices.

The study revealed that cooperatives and processors, such as Bio Foods, provide significant support to farmers, such as training farmers and implementing practices that ensure that milk meets the required

standards. However, stakeholders not involved with Bio Foods did not implement these practices. Collaboration between Bio Foods and the Kenya Dairy Board (KDB) was noted to be essential for integrating stakeholders outside the Bio Foods supply chain.
The study identified that a comprehensive range of strategies is necessary to improve milk quality and lower contaminant levels, enabling farmers to integrate into the formal channel. This included implementing broad interventions across the value chain. Effective strategies involve:
Farmers: Adopting good farming practices to ensure milk quality.
Feed suppliers and service providers: Providing high-quality products and services to farmers.
Bio Foods: Actively train farmers to meet required standards and ensure their milk is conform standards, collaborate with other chain actors like KDB and other cooperatives, and link farmers to reputable input suppliers.

Recommendations
Three recommendations were put forward to Bio Foods as areas of intervention.
1. Create partnerships with more cooperative societies like the ones involved in this study. This would involve onboarding the cooperatives as new milk suppliers. These cooperatives were already established with high volumes of milk. But first, Bio Foods has to take them through a training and onboarding process to ensure consistency in the quality of the milk.
2. Create collaborations with private companies in Kenya, especially those in the feed industry working with international standards and link farmers to these companies. This would allow farmers to access quality products with low contaminant levels. When farmers use these products, their milk conforms to Bio Foods' required standards and can be onboard with Bio Foods.
3. Bio Foods to provide farmers with incentives to encourage them to shift from the spot market.

Impact
Implementation of the recommended interventions by Bio Foods will allow Bio Foods farmers for the production of high-quality milk, meeting the required standards, increasing their intake and meeting the market demand.

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Food Loss along the Dairy Value Chain: Effects of Different Nutritional Practices of Dairy Cattle Farmers and the Impact on Milk Loss and Wastage in Bungoma County, Kenya

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Practice Brief
FORQLAB Project 2024-07

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

In Kenya, dairy farming is the most common economic activity in the entire agriculture sector; estimated to have 4 per cent of the gross domestic product (GDP) share of the total GDP (Wamuyu, 2020). Additionally, Dairy farming forms the largest part of the farming activity in the agricultural landscape in Bungoma County, Western Kenya, and serves as one of the major sources of livelihood for many households that substantially boost the economic growth of the area. On the other hand, this area has been facing major challenges, especially in the nutritional management that has a negative effect on milk production, quality, and profitability. These nutritional challenges, coupled with them, are other menaces: aflatoxin contamination in milk and feeds, that can lead to serious health risks to consumers and economic losses to producers. Feeding management practices at the farm level could majorly affect milk losses and wastage through improper feeding programs. This brief shares findings from FORQLAB study on (i) the nutritional value of dairy cattle feed resources; (ii) feeding practices and their effect on milk yield, and (iii) feed and milk quality parameters in the Kaptama and Kitinda MCCs. The results from the study provide background information to advise stakeholders in the dairy value chain on the best approaches to optimize productivity and lessen food losses and waste.

Nutritional composition and *in vitro* digestibility of dairy cattle feed resources

Nutritional values of the main dairy cattle feed resources were evaluated through proximate and *in vitro* digestibility analyses. The feeds were grouped into 25 diets using a completely randomized design (CRD). A chemical analysis was conducted to determine the nutrient composition. The *in vitro* organic matter digestibility was determined using the gas production method for all experimental diets. Data collected on proximate analysis was subjected to the analysis of variance in a CDR using the General linear Model procedure of Statistical Analysis System version 9.4.

Results and discussion

The results for the proximate composition of sampled feed roughages are shown in Table 1. The roughages displayed a diverse range of dry matter (DM) content, varying from 904.1 g/kg DM to 936.1 g/kg DM. The ash content of different roughages varied significantly (p<0.05), with panicum having the highest value at 130.8 g/kg DM. Conversely, oats had the lowest amount at 27.0 g/kg DM. Super Napier had the highest crude protein (CP) content at 149.3 g/kg DM.

Table 1. Chemical composition for roughages in g/Kg^{-1}DM

	Parameters							
Sample	DM	Ash	EE	CF	CP	NDF	ADF	ADL
Kikuyu grass	932.8^{bcd}	97.8^{gh}	15.0^{jkl}	307.9^{f}	146.4^{e}	693.2^{c}	424.7^{de}	75.5^{ed}
Bracharia	936.1^{abc}	85.4^{ij}	39.7^{de}	340.5^{de}	107.1^{fgh}	617.4^{ef}	277.3^{i}	48.7^{i}
Boma Rhodes	910.2^{jk}	88.4^{i}	16.2^{ijk}	362.0^{bc}	89.7^{ij}	526.3^{h}	390.6^{f}	20.8^{k}
Panicum	936.0^{abc}	130.8^{d}	16.5^{ijk}	357.2^{cd}	101.3^{hij}	598.5^{f}	506.4^{b}	70.6^{ef}
Super Napier	920.8^{fghi}	115.2^{f}	42.0^{de}	379.8^{b}	149.3^{e}	733.3^{ab}	432.0^{d}	63.7^{fg}
Elephant Grass	925.1^{defg}	101.3^{g}	34.2^{ef}	333.5^{e}	86.8^{j}	710.2^{bc}	390.4^{f}	66.7^{fg}
Oat grass	904.1^{k}	27.0^{o}	60.9^{c}	349.9^{cde}	107.6^{fg}	626.5^{ef}	492.1^{bc}	72.3^{def}
Maize Silage	935.9^{abc}	69.7^{k}	19.7^{hij}	341.0^{de}	56.1^{k}	474.7^{ij}	361.7^{g}	64.7^{fg}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b, c, d, e, f, g, i, j, k, l means in the same column with different superscripts are significantly different at p<0.05). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

The CP content of maize silage was 56.1 g/kg DM, and this can be due to changes in maize quality and harvesting stages. The fiber content of different roughages varied, with Super Napier having the highest neutral detergent fiber (NDF) content at 733.3 g/kg DM and maize silage having the lowest at 474.7g/kg DM. ADF ranged from 277.3 g/kg DM to 492.1 g/kg DM for Brachiaria and oats, respectively. The crop residues exhibited varying chemical compositions, with dry matter (DM) ranging from 888.3 g/kg DM (potato peels) to 942.6 g/kg DM (banana leaves), as shown in **Table 2.** The ash content of groundnut residues was the highest at 161.9 g/kg DM, while sugarcane tops had the lowest ash content at 62.9 g/kg DM. Similarly, the groundnut residue had the highest crude protein (CP) content at 114.6 g/kg DM while sugarcane tops had the lowest CP content at 27 g/kg DM. The fiber composition of crop residues exhibited significant variation, with bean residues having the highest NDF content at 732.1 g/kg DM. Potato peels had the lowest NDF level at 92.2 g/kg DM. Comparable patterns were noted in ADF and acid detergent lignin (ADL).

Table 2. Chemical analysis for Crop Residues in g/Kg^{-1}DM

	Parameter							
Sample	DM	Ash	EE	CF	CP	NDF	ADF	ADL
Bean Residue	938.9^{ab}	124.2^{e}	23.7^{ghi}	490.1^{a}	60.8^{k}	717.2^{abc}	615.1^{a}	105.1^{c}
Millet Residue	915.1^{hij}	116.1^{f}	6.5^{l}	361.0^{bc}	55.6^{k}	658.7^{d}	399.2^{ef}	58.8^{gh}
Groundnut residue	921.1^{fgh}	161.9^{b}	11.0^{kl}	203.4^{i}	114.6^{f}	474.7^{ij}	390.1^{fg}	67.8^{ef}
Potato Peels	912.1^{ijk}	64.9^{l}	11.0^{kl}	115.8^{l}	95.5^{hij}	92.2^{n}	70.5^{n}	11.9^{l}
Maize Stover	930.8^{bcde}	34.0^{m}	8.7^{kl}	336.4^{e}	59.0^{k}	451.7^{jk}	238.1^{j}	35.6^{j}
Sugarcane Tops	935.1^{abc}	62.9^{l}	46.2^{d}	362.5^{bc}	27.8^{l}	645.9^{de}	427.9^{d}	71.6^{ef}
Banana Leaves	942.6^{a}	122.2^{e}	39.2^{de}	139.8^{k}	110.0^{fg}	732.1^{ab}	586.7^{a}	135.2^{b}
Banana stems	928.3^{l}	152.3^{c}	30.5^{fg}	278.4^{a}	5.73^{k}	566.9^{g}	415.8^{def}	80.4^{d}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b,c,d,e,f,g,h,j, k,l,m,n,o,p means in the same column with different superscripts are significantly different at $p<0.05$). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

The CP content of fodder trees and legumes varied between 240.7 g/kg DM and 183.4 g/kg DM. These findings emphasize the significance of comprehending the nutritional composition of different feed resources. They also emphasize elements such as plant species, harvesting stages, and planting methods that affect their chemical profiles. This information is crucial for optimizing livestock feeds and ensuring the health and efficiency of animals.

Table 3. Chemical composition of fodder trees, legumes, concentrates, and total mixed rations (g/KgDM)

	Parameter							
Sample	**DM**	**Ash**	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Sesbania	925.6^{def}	61.6^{l}	25.2^{gh}	273.0^{h}	240.7^{a}	742.0^{a}	605.1^{a}	185.7^{m}
Leuceana	933.4^{bcd}	50.2^{m}	60.5^{c}	170.1^{j}	201.4^{c}	308.2^{m}	110.1^{m}	20.9^{k}
Calliandra	894.8^{l}	121.7^{e}	14.7^{jkl}	201.6^{i}	228.0^{b}	620.3^{ef}	469.6^{c}	53.7^{ih}
Lucerne	928.6^{cdef}	95.4^{h}	21.2^{hij}	196.1^{i}	195.0^{c}	397.9^{l}	319.4^{h}	67.5^{efg}
Desmodium	904.2^{k}	170.2^{a}	78.3^{b}	293.2^{fg}	197.3^{c}	517.0^{h}	248.5^{j}	66.5^{fg}
Sweet Potato vines	916.9^{ghij}	70.4^{k}	41.9^{de}	188.9^{ij}	183.4^{d}	443.4^{k}	209.5^{k}	34.9^{j}

Maize Bran	932.6^{bcd}	14.7^{p}	90.4^{a}	87.1^{m}	89.1^{j}	483.0^{i}	225.4^{jk}	18.9^{kl}
Dairy Meal	923.6^{efgh}	83.8^{j}	63.1^{c}	172.2^{j}	116.3^{f}	280.3^{m}	152.1^{l}	16.9^{kl}
Total mixed ration	928.7^{cdef}	26.9^{o}	42.2^{de}	116.8^{l}	102.4^{gh}	373.4^{l}	177.1^{l}	20.9^{k}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

$^{a,\ b,c,d,e,f,g,h,\ l,j,k,m,n,o,p}$ means in the same column with different superscripts are significantly different at $p<0.05$) DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

Effect of feeding practices on quality and aflatoxin levels of milk

As a crucial dietary component, milk provides significant nutritional benefits but carries health risks if contaminated. Aflatoxin contamination in dairy products has repeatedly breached the World Health Organization's safety thresholds in Kenya, particularly in Bungoma County. Addressing this issue is crucial for ensuring public health and supporting the dairy sector's economic viability. To contribute to public safety, this study aimed to determine the effect of feeding practices on nutritional quality and aflatoxin levels of milk in Kitinda and Kaptama milk collection centres.

Materials and Methods

Milk was sampled from 25 dairy farmers affiliated with the Kaptama and Kitinda cooperatives. Milk quality parameters including raw milk butterfat and protein content, as well as milk density were analysed using the Gerber, Kjeldahl, and lactometer methods, respectively. Aflatoxin levels were determined through enzyme-linked immunosorbent assay (ELISA).

Results and discussion

The samples from 12 different farmers in Kitinda milk collection centres showed significant differences ($p<0.05$) in crude protein, butterfat, and density as shown in **Table 4.** The crude protein content ranged from 2.257% Kitinda 2(KTD2) to 4.225% Kitinda 5(KTD5). Butterfat content varied significantly ($p<0.05$) with 2.5% Kitinda 12(KTD12) as the lowest while Kitinda 1(KTD1) was the highest with 3.4%. There was no significant difference ($p>0.05$) in density.

Table 4. Milk Quality and safety parameters analysis from 12 farmers in Kitinda

Sample	**Crude Protein (%)**	**Butterfat (%)**	**Density(g/cm^3)**	**AFM1(µg/kg)**	**Total AF(µg/kg)**
KTD1	3.356^{ab}	3.400^{a}	1.027^{bc}	510.7024	72.43339
KTD2	2.257^{c}	2.550^{fg}	1.026^{bc}	706.4979	2.48013
KTD3	3.500^{ab}	2.900^{cde}	1.027^{bc}	27.59411	3.431099
KTD4	3.067^{bc}	2.650^{fg}	1.025^{e}	3.245964	2.160466
KTD5	4.225^{a}	2.650^{fg}	1.027^{bc}	8.946678	2.547904
KTD6	2.951^{bc}	2.950^{bcd}	1.028^{a}	560.9281	54.94629

KTD7	4.109^{a}	2.750^{def}	1.027^{c}	583.2436	5.349014
KTD8	2.720^{bc}	2.550^{fg}	1.024^{e}	17.60196	32.17325
KTD9	3.647^{ab}	2.700^{efg}	1.029^{e}	2.064722	2.871726
KTD10	3.414^{ab}	3.100^{bc}	1.028^{a}	4.1926	1.324459
KTD11	3.125^{bc}	3.150^{b}	1.028^{a}	10.1935	2.412922
KTD12	3.125^{bc}	2.500^{g}	1.025^{e}	0.000	0.000
Ave	3.291	2.821	1.027	202.934	15.178
SD	0.528	0.270	0.001	277.170	23.470
SEM	0.181	0.040	0.000	0.000	0.000
p-value	<.0001	<.0001	<.0001	<.0001	<.0001

[a, b, c, d, e, f, g] means in the same column with different superscripts are significantly different at p<0.05) KTD= Kitinda and 1,2,3….12= 12 different sampled farmers, Ave= average, SD= standard deviation

The analysis of quality indicators (crude protein, butterfat, and density) from samples collected from 13 farmers in Kaptama reveals statistically significant variations (p<0.05) among the samples as shown in **Table 5**. The crude protein content exhibited significant variations (p<0.05), ranging from a low value of 2.430% in sample KTM10 to a high value of 4.572% in sample KTM3. The butterfat concentration exhibited significant variance (p<0.05), ranging from 2.450% in samples KTM6 and KTM10 to 3.550% in sample KTM5. The density values varied between 1.025 in samples KTM4, KTM7, and KTM10, and 1.030 in samples KTM5 and KTM11.

Table 5: Milk Quality and safety parameters analysis from 13 farmers in Kaptama

Sample	**Crude Protein (%)**	**Butterfat (%)**	**Density (g/cm$^{3)}$**	**AFM1(µg/kg)**	**Total (µg/kg)**
KTM1	4.167^{a}	3.350^{d}	1.0287^{c}	560.9281	87.1428
KTM2	2.604^{bc}	2.900^{g}	1.0267^{d}	832.4809	3.29422
KTM3	4.572^{a}	3.050^{f}	1.029^{ab}	13.73016	4.443101
KTM4	3.704^{ab}	2.700^{h}	1.025^{e}	20.9206	3.269543
KTM5	3.588^{abc}	3.550^{a}	1.030^{ab}	11.27983	53.16964
KTM6	2.546^{bc}	2.450^{i}	1.028^{cd}	49.79994	65.12169
KTM7	3.414^{abc}	2.700^{h}	1.025^{e}	48.066	29.77031
KTM8	3.762^{ab}	3.150^{e}	1.027^{d}	2.819976	3.608137
KTM9	4.514^{a}	3.450^{bc}	1.029^{ab}	44.48113	2.731415
KTM10	2.430^{c}	2.450^{i}	1.025^{e}	848.6603	4.511939
KTM11	4.167^{a}	3.500^{ab}	1.030^{a}	20.51247	3.749449
KTM12	3.646^{abc}	3.050^{f}	1.027^{cd}	88.48283	3.331356
KTM13	3.704^{ab}	3.400^{cd}	1.028^{bc}	66.6546	4.360973
Ave	3.601	3.054	1.028	200.678	20.654
SD	0.678	0.374	0.002	306.200	27.910
SEM	0.236	0.019	0.000	0.000	0.000
p-value	<.0001	<.0001	<.0001	<.0001	<.0001

[a, b, c, d, e, f, g,h,i] means in the same column with different superscripts are significantly different at p<0.05) KTM= Kaptama and 1,2,3….12= 12 different sampled farmers, Ave= average, SD= standard deviation

Milk quality

The results indicate statistically significant variations, whereby in Kitinda, crude protein content varied from 2.257% to 4.225%, with the highest values reported in samples KTD5 and KTD7. This variability could be attributed to differences in cattle diet or genetics that affect protein synthesis. Kaptama showed a similar trend in protein variation, ranging from 2.430% to 4.572%, with the highest protein level observed in sample KTM3. The data from both regions suggest that some farmers might have superior feeding strategies or cattle breeds that are genetically predisposed to higher protein production.

Butterfat content showed significant differences within both regions. In Kitinda, butterfat levels ranged from 2.5% (KTD12) to 3.4% (KTD1). In Kaptama, these levels were slightly wider, from 2.450% (KTM6, KTM10) to 3.550% (KTM5). The variation in butterfat content is typically influenced by the stage of lactation and diet and are critical as they affect product processing and marketability. The density of milk, which reflects its total solids content, showed no significant variation in Kitinda but did vary in Kaptama. Factors affecting milk density include the solids content (both fats and proteins) and potential adulteration practices such as water addition.

The implications of these findings are significant for local dairy farming and product development. They highlight the need for targeted interventions that could include farmer education on best practices, improvements in cattle genetics, and perhaps the formation of cooperative groups to standardize milk quality. Such efforts could enhance both the nutritional value of milk and its commercial viability.

Aflatoxins in feed and milk

The recommended amount of total aflatoxins in feeds is usually 20 µg/kg (Thakur, et al.,2022). From the study, the majority of the samples had levels that were within the required standards (69.23% and 76.47%) in Kitinda and Kaptama, respectively, as shown in Figure 1. However, Kitinda recorded the highest levels (30.77%) of aflatoxins above the recommended range. On the other hand, Kaptama had (23.53%). The significant proportion of animal feed samples exhibiting total aflatoxin contamination exceeding the international threshold indicates a potential long-term exposure of animals and individuals to aflatoxins through their diets (Kamala et al., 2018; Kotinagu et al., 2015). From the study, the high percentages (30.77%, 23.53%) in Kitinda and Kaptama respectively corroborates results from Makori et al. (2019) who found that inadequate postharvest handling methods of animal feeds by both suppliers and consumers could have contributed to higher levels of aflatoxin contamination. Furthermore, inefficient processing methods, such as inadequately drying animal feed materials and improper differentiation between infected and uncontaminated raw animal feed materials (Shabani et al., 2015), also contribute to the increased presence of aflatoxin throughout the supply chain.

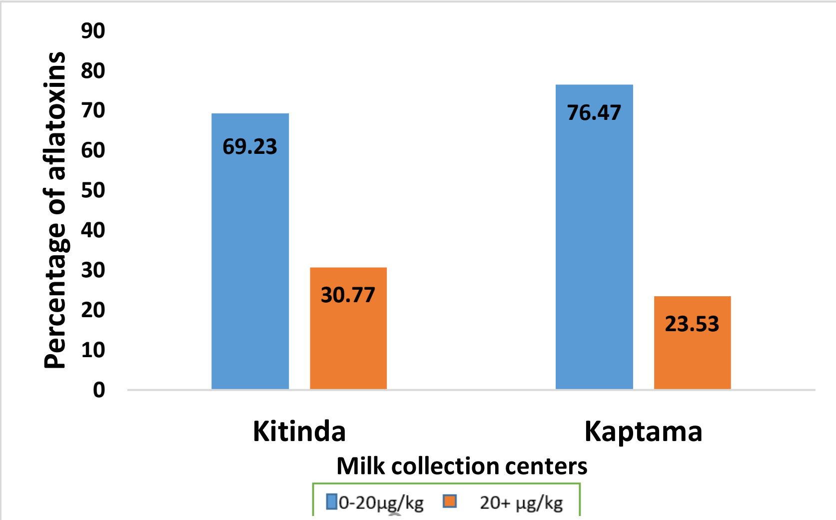

Figure 1. A graph showing the total aflatoxins in feeds in Kaptama and Kitinda

The level of aflatoxins M1 that is recommended in raw milk is typically 50 µg/kg (Zebib et al,2022). From the findings of the study, the majority of the samples had levels that were within the recommended limits (61.54% and 70.59%) in Kitinda and Kaptama, respectively as shown in **Figure 2**. On the other hand, Kitinda had the highest amounts of aflatoxins at 38.46%, which is significantly higher than the permitted threshold. Kaptama, on the other hand, had a percentage of 29.41% of the M1 aflatoxins as a result of variation in diets. The disparity in contamination levels between the two locations may potentially indicate distinct local differences in the storage and handling methods of animal feed.

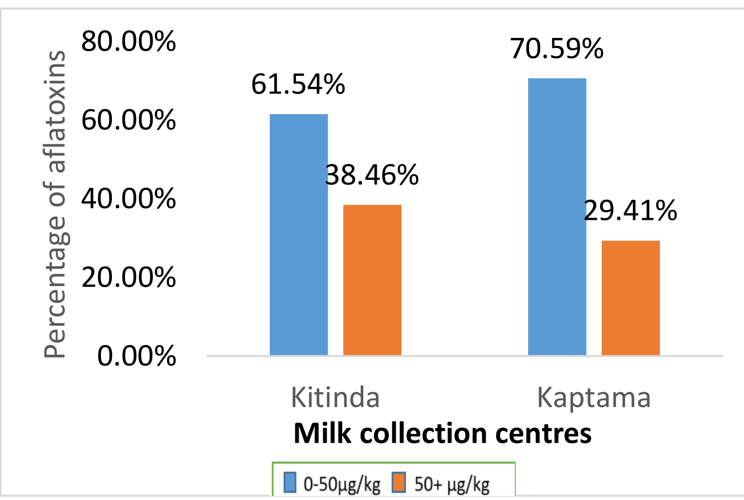

Figure 2. Aflatoxins (M1) in raw milk from Kitinda and Kaptama MCCs

Correlation analysis of aflatoxins in feeds and milk

Aflatoxin levels in feed and milk were all investigated for associations using Pearson correlation analysis. There was a significant difference between feed and milk (*p > 0.01*), indicating a strong association between the two **(Table 6).**

Table 6. Pearson correlation for total aflatoxins in feed and milk

	Feed	**Milk**
Feed	1	.749**
Milk	.749**	1

****Correlation is significant at the 0.01 level (2-tailed correlation).**

The strong Pearson correlation coefficient of 0.749 indicates a strong positive correlation between aflatoxin levels in feed and milk. The role of this correlation shows how aflatoxins, powerful carcinogens produced by *Aspergillus* fungi, contaminate the dairy supply chain, creating significant health risks.

Dairy cattle feeding practices, losses, and wastage and their impact on milk yield

Dairy cattle feeding practices, losses and wastages, general dairy performances as well as attitudes of dairy farmers in Kaptama and Kitinda MCCs was determined. A total of 200 farmers were sampled using a stratified sampling technique and structured questionnaires were administered. Findings indicate that 77.5% of farmers experience significant losses primarily due to feed-related factors (44%) and health issues (19.5%). Most farmers (90.5%) acknowledge a direct link between feeding practices and milk yield, with 84.5% observing variations in milk yield due to different feeding methods. Additionally, the study reveals that 51% of farmers rely mainly on crop residues for feed, with 71% feeding their cattle twice daily. Also, 58% of farmers rated their milk production performance as poor, highlighting widespread challenges in dairy farming practices. Overall dissatisfaction with current dairy farming practices is high, with 34% of farmers very dissatisfied and 40.5% dissatisfied.

The study's participant demographic distribution shows that there is a varied representation of gender in the Kaptama and Kitinda dairy farming communities as shown in **Table 7**. The gender distribution of the 200 participants is shown by the tabulated data, which shows that 73 of them were men, made up 36.5% of the sample, while 127 of them were women, and made up 63.5%. The study's inclusiveness is highlighted by the gender distribution, which captures the viewpoints and experiences of both male and female participants in the dairy farming industry. The importance of gender dynamics in agricultural contexts must be recognized because they have the potential to affect many facets of farm management, decision-making, and the adoption of novel practices.

Table 7. Gender Distribution of the Participants

Gender	Frequency	Percent (%)
Male	73	36.5
Female	127	63.5
N	200	100

Table 8. Location Distribution of the Participants

Kaptama	108	54.0
Kitinda	92	46.0
N	200	100

Table 9. Level of Education Distribution of the Participants

Primary	89	44.5
Secondary	90	45.0
Tertiary	21	10.5

N= 200

The study on participants' educational backgrounds demonstrate a wide range of academic achievement within the Kaptama and Kitinda dairy farming communities as shown in **Table 9**. A sizeable fraction of the sample, 44.5%, has completed their primary schooling, suggesting that a sizable portion of people who work in dairy farming have a basic education. This implies that a sizable portion of participants have picked up the necessary reading and numeracy abilities. 45.0% of the sample is another significant group of participants who have completed secondary school. This distribution suggests that people with educational backgrounds beyond the primary level are fairly evenly represented. Secondary school graduates may add new abilities and expertise to their farming methods, which could have an impact on decision-making procedures and the uptake of cutting-edge agricultural practices.

Furthermore, a smaller but significant percentage representing 10.5% of the participants—has gone on to complete their postsecondary education. This group includes people with more education, suggesting a subset of participants with more sophisticated skill sets and possibly deeper knowledge of agricultural practices. Individuals with tertiary education may possess specialized knowledge that can be applied to improve farm management practices and possibly develop novel approaches in the dairy industry.

Comprehending the educational background of the participants is imperative in the interpretation of results concerning nutritional practices, milk quality, and the overall performance of dairy products (Sharma, 2016). A person's ability to understand and apply advice, interact with agricultural extension services, and embrace sustainable farming methods can be influenced by their level of education.

The mean age of the respondents is 49.62 years, with a minimum age of 21 years and a maximum age of 87 years as shown in **Table 10**. The participants' ages showed a moderate degree of variability, as indicated by the standard deviation of 13.745. This demographic information sheds light on the sample's generational diversity, which may have an impact on attitudes and farming methods. The age distribution of the participating farmers provides insight into the dynamics between generations in the community of dairy farmers. Our understanding can be further enhanced by analysing experience in dairy farming and determining whether patterns in practices and attitudes can be identified based on the duration of time that individuals have been involved in dairy-related activities.

Table 10. Age and Lactating animals per household

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age of the Respondent	200	21	87	49.62	13.745
Size of the family	200	2	13	5.74	2.386
Number of lactating animals	200	1	4	2.26	1.025
Valid N (listwise)	200				

The size of the family affects how resources are allocated, how decisions are made, and how the farm is managed. Larger families may have a broader labour force, enabling them to engage in a more extensive range of farming activities. On the other hand, smaller families may encounter distinct difficulties in handling the variety of responsibilities linked to dairy farming. Bigger families could need more resources and encounter particular difficulties in providing for each member's needs, including both human and animal members of the household. In this study, it is shown that there is an average family size of 5.74 members, family sizes range from a minimum of 2 to a maximum of 13. Family sizes appear to vary to a considerable extent, as indicated by the standard deviation of 2.386. Determining how resources are allocated, decisions are made, and household dynamics are generally evaluated in the context of dairy farming; this requires an understanding of family structure.

Examining the study cohort's dairy farming landscape, it is significant to note that, on average, participants reported owning 2.26 lactating animals per household. One to four lactating animals are the maximum number of animals capable of being owned. The standard deviation of 1.025 indicates the presence of some variability in the number of animals that are lactating. This specific variable has important ramifications for different aspects of dairy farming. The quantity of lactating animals directly impacts milk production, which is a critical factor in determining the total amount of dairy products produced in a household. Furthermore, the differences in the number of lactating animals highlight the various dairy operation sizes among participants, indicating different approaches to maintaining and caring for their animals.

The dairy cattle feeding practices, losses, wastages, and their effect on milk yield

Diverse feed resources used in this region were identified whereby the majority of the farmers (51%) feed crop residue as the main feed, followed by fodder trees and legumes (21.5%), roughages (14%), and obtain concentrate and total mixed ration (TMR) (13.5%) as shown in **Figure 3.** The feeding frequency was recorded twice daily (71%). This clearly shows a bit of organized feeding time, with the majority of farmers giving cows feed in the morning and afternoon (38.2%) or morning and evening (34.2%).

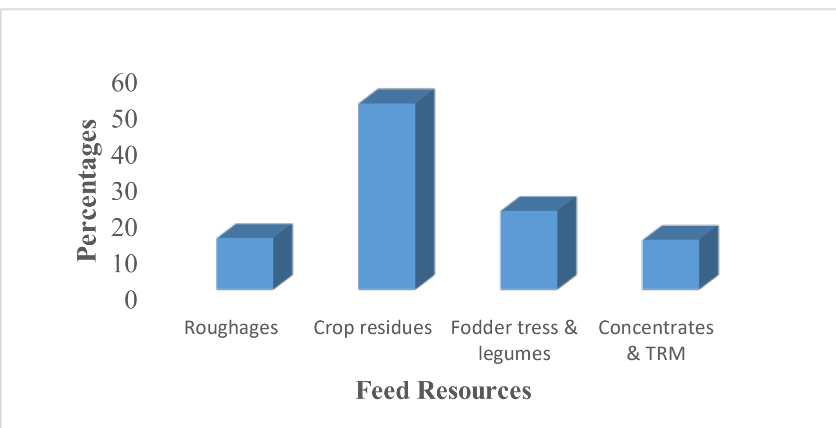

Figure 3. Main feed resources in Kaptama and Kitinda

The majority of farmers (77.5%) experienced losses or wastages in their practices, most commonly due to feed-related factors (44%) and health matters (19.5%) as shown in Figure 4 below. Results suggest a high level of acceptance among farmers (90.5%) that feeding practices are directly linked with milk yield, with 84.5% of farmers witnessing sometimes effects in milk yield through different feeding practices.

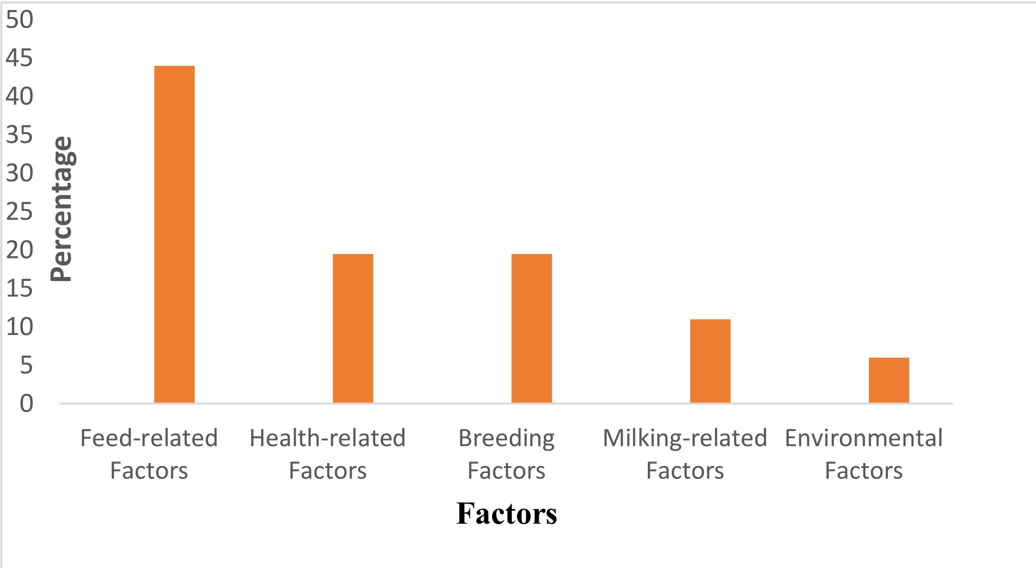

Figure 4. Causes of losses and wastages in milk in Kaptama and Kitinda MCCs

The general dairy performance and attitudes of dairy farmers

The survey results show that 9.5% of respondents assessed their dairy cattle's performance as "Very Poor." This is a crucial realization because it implies that a small percentage of farmers are dealing with significant problems impacting their output. When farmers do not use current dairy farming techniques or do not have access to better feeding regimens, these problems tend to worsen. As the rating increases, 19.0% of farmers consider the performance of their livestock to be "Poor." This group will likely face challenges that significantly impede their operation's production. As indicated by the "Neutral" rating given by the majority of respondents (54.5%), the productivity of their cattle merely satisfies fundamental expectations without surpassing them. Several factors, such as genetic potential, feed quality, and management techniques that are adequate but not exceptional, could contribute to this feeling of inadequacy.

Conclusions

- **Diverse nutritional profiles across feed types:** The study revealed significant variability in the proximate composition of the analyzed feed resources, including roughages, crop residues, fodder trees, legumes, concentrates, and total mixed rations. This variation highlights the necessity of careful feed selection for optimal animal performance.
- **Low-quality crop residues:** Most crop residues exhibited lower CP content and higher fiber fractions. *Sugarcane tops* and *maize stover*, for instance, had low CP and high NDF and ADF, indicating limited nutritive value unless supplemented or treated. Fodder trees and legumes have better nutritional profiles, while crop residues are of low quality.
- **Nutritional quality variability**: Significant differences in crude protein and butterfat content were observed across samples from both regions, which can be attributed to factors such as cattle breed, feeding regimen, and lactation stages. Milk density showed significant variation in Kaptama but not in Kitinda, possibly due to adulteration practices or environmental conditions.

- **Aflatoxin contamination**: A substantial proportion of animal feed and raw milk samples in both Kitinda and Kaptama contained aflatoxins above recommended safety limits, with Kitinda showing slightly higher levels. The presence of aflatoxin M1 in milk suggests dietary exposure to contaminated feed, posing a public health concern**.**
- **Correlation of contaminants**: A **strong positive correlation** (r = 0.749) between aflatoxin levels in feed and milk was established, confirming that contaminated feeds significantly contribute to milk contamination.
- **Gender Representation:** The study recorded a gender-inclusive sample with 63.5% female and 36.5% male participants. This gender distribution indicates that women play a significantly larger role in dairy farming in Kaptama and Kitinda. This reflects growing inclusivity and provides an opportunity to tailor interventions and training that are gender sensitive.
- **Educational Background:** The participants' education levels varied, with most having completed primary (44.5%) or secondary (45%) education, and a smaller segment having tertiary education (10.5%). The predominance of basic to intermediate educational attainment suggests that training and extension materials should be developed using simple, visual, and practical communication approaches.
- **Demographics and Household Dynamics:** The mean participant age was 49.62 years, indicating a mature and experienced demographic, with variability in age and family size. The average household size of 5.74 members points to potential family labor availability, though it also implies resource strain. Most households had 2–3 lactating animals, reflecting smallholder-scale dairy operations.
- **Feeding Practices and Challenges:** Crop residues were the most commonly used feed (51%), but concerns about feed quality (52%), feed loss (13%), and unbalanced rations (13.5%) were prevalent. Feeding frequency was largely consistent (twice daily), yet 77.5% of farmers reported losses—mainly due to poor feed and animal health. These issues directly impacted milk yield and quality, which most farmers acknowledged.
- **Low Performance and Dissatisfaction:** There was a notable dissatisfaction with dairy productivity and milk quality, with 34.5% and 49.5% rating them "very poor," respectively. This dissatisfaction is echoed in overall farmer sentiment, with 74.5% expressing discontent with current practices. Despite this, 88% understood the direct link between nutrition and milk quality, showing high awareness but limited capacity to act.

Recommendations

- **Utilization of Crop Residues:** While crop residues such as *maize stover* and *sugarcane tops* have limited nutritive value, their abundance makes them viable basal feeds. However, they should be treated (e.g., urea treatment) or supplemented with protein-rich forages to improve their usability.
- **Promotion of Fodder Legumes:** Encourage the integration of high-protein fodder legumes (e.g., *lucerne*, *desmodium*, *leuceana*) into feeding systems to increase protein supply, improve fermentation, and support animal productivity.

- **Feed Conservation Strategies:** Due to the high quality of some seasonal forages (e.g., *Super Napier*, *lucerne*), proper conservation through hay or silage making should be promoted to ensure year-round availability.
- **Routine Feed Quality Assessment:** Farmers and feed formulators should be encouraged to perform periodic chemical analyses to monitor feed quality, given the significant variation observed due to species, maturity stage, and management practices.
- **Farmer Training and Capacity Building**: Train farmers on optimal cattle feeding practices, reduction of aflatoxins, proper feed handling and storage techniques including nutrient-rich diets and breed selection, to enhance milk quality.
- **Improvement of Feed Processing and Storage** through efficient postharvest handling and drying methods to reduce fungal growth and aflatoxin production in animal feed and regular monitoring and quality control along the feed supply chain.
- **Enhance Milk Handling and Quality Control Systems:** Introduce affordable milk testing kits, hygiene training, and cooling/storage technologies at household and collection center levels to reduce spoilage and improve quality. Establish stronger linkages with milk processors and buyers that offer premiums for quality.
- **Policy and Regulatory Support**: Support the farmer cooperatives to help standardize milk quality and improve access to safer, processed feed.

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Effect of Digital Financial Services on performance of smallholder dairy farmers in Bungoma County

Wilson Munene Karimi, Dickson Otieno Okello, Florence A Opondo, Victor Kiplangat.

Practice Brief FORQLAB Project 2024-08

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Introduction

In Kenya, smallholder farmers account for about 80% of the milk produced with majority selling in the informal markets that control 80% of raw milk sold in the country. The remaining 20% is sold to cooperatives and processors. In such a market, the dynamics of milk production, market access, cost management, and milk loss mitigation play crucial roles in shaping the fortunes of dairy farmers. Challenges such as limited access to breeding services, inefficient milk collection and marketing systems, extension and training, insufficient and poor-quality feeds for dairy cattle, occurrence of livestock diseases and inadequate access to credit facilities hinder progress (Odero-Waitituh, 2017; Onono and Ochieng, 2018; Rademaker *et al.,* 2016).Digital financial services (DFS) have continued to shape the performance of smallholder farmers across the globe replacing the traditional banking services. Among the DFS currently being spearheaded are digital payments, credit, insurance, savings, and remittances. Despite its significant growth, there is paucity of information regarding the choice of the DFS, their acceptance level and the degree to which usage of these DFS influences the performance of smallholder dairy farmers. Smallholder dairy farmers in Bungoma County, Kenya, face persistent production and marketing challenges. The DFS offer promising solutions, but the adoption and impact among these farmers remain underexplored. This brief shares findings from a FORQLAB study on DFS usage and its influence on farm productivity, milk income, and resilience in the dairy value chain.

Methodology

The study used a quantitative research design with cross-sectional survey data from a sample of 384 smallholder dairy farmers in Mt Elgon and Kanduyi, Bungoma County. The target population for the study were smallholder dairy farmers in Kitinda and Kaptama dairy cooperatives. Multistage sampling techniques was used determine the study's designed sample size. The study’s data was gathered through scheduled interviews with smallholder dairy farmers, using questionnaires as the primary data collection tool. The quantitative data was analyzed descriptively and inferentially using Stata 16 using frequencies, percentages, means, and standard deviation and presented using tables and figures.

Key Findings

- **Perceived Usefulness and Behavioral Control:** The study found that perceived usefulness and personal behavioral control are strong predictors of farmers' intention to use digital financial services (DFS). Notably, perceived usefulness fully mediates the relationship between personal behavioral control and DFS usage intention—indicating that confidence in using DFS must be matched by a clear understanding of its benefits.
- **Demographic Influences:** Adoption of DFS is lower among older farmers and male respondents, while larger household sizes, access to formal credit, and higher digital financial awareness are positively correlated with DFS usage.
- **Barriers to Adoption:** Key obstacles include informal market structures, low trust in digital transactions, and limited outreach of formal financial institutions in rural areas.
- **Impact of DFS Combinations:** The effects of DFS on milk income and productivity vary depending on the combination of services used. While integrated use of multiple DFS types generally leads to better outcomes, certain limited combinations (e.g., payments and credit only) may yield suboptimal or even negative results.

Digital financial usage among smallholder dairy farmers

Study findings revealed that the majority of the smallholder dairy farmers (31%) used digital payment services (DPS) compared to other DFS. This indicates that DPS have received significant attention and are essential with the dynamic changes in payment of services globally. This is also attributed to the convenience and efficiency that the DPS offer allowing farmers to save on transaction costs of travelling, secure transactions and is most beneficial to rural areas where access to traditional banking systems is limited. Digital saving services (DSS) and digital credit services (DCS) followed closely at 27% and 26% respectively. Digital remittance services (DRS) usage accounted for 12% while digital insurance services (DIS) (3%) was the least used service among smallholder dairy farmers. The lower usage of DRS (12%) suggests that remittances may not be as prevalent among this demographic, potentially due to factors such as limited migration or reliance on other forms of financial support. In the case of DFS, the majority of the smallholder dairy farmers may lack awareness of the insurance services and may not have adequate knowledge on the benefits hence the low usage.

Determinants of usage of digital financial services competitive strategic choices among smallholder farmers

The study revealed several critical factors influencing the use of DFS among smallholder dairy farmers in Bungoma County. Age negatively impacted the adoption of digital payments, credit, and remittance services, largely due to limited digital literacy, lack of access to technology, and a preference for traditional cash methods among older farmers. Similarly, gender played a role, with males showing lower usage of digital payments, savings, and insurance services. This aligns with existing literature highlighting gender disparities in access to technology and financial education. Household size, on the other hand, had a positive influence on the use of DFS, likely due to increased financial complexity and demand for efficient solutions in larger households. Experience in dairy farming also positively influenced the use of digital payments, suggesting that more experienced farmers are more financially savvy and open to technological solutions.

Other contextual factors shaped DFS adoption significantly. Poor road infrastructure negatively affected the use of digital remittance and insurance services, limiting physical access to service providers and training opportunities. Trust dynamics also played a pivotal role—farmers who trusted milk buyers were more inclined to use digital payment services but showed less reliance on digital credit and remittance options. Interestingly, group membership, while important for resource sharing and information, had a negative impact on the use of digital credit, savings, and insurance services, possibly due to reliance on informal group-based financial systems. Furthermore, access to extension services was found to negatively affect digital payment adoption, likely due to a lack of focus on digital financial inclusion in traditional agricultural extension programs. Market-related and institutional factors also influenced DFS usage. Milk markets negatively impacted digital payments and savings, likely due to informal and unpredictable market structures. Conversely, the presence of buyer-written contracts encouraged the use of digital savings and remittance services by offering farmers more financial security and transparency. Access to credit significantly boosted the usage of all digital financial services, highlighting its enabling role in DFS adoption. Finally, digital financial awareness emerged as a crucial driver of DFS utilization, reinforcing the importance of education and training in empowering farmers to embrace digital tools confidently and effectively.

Conclusions

- How useful farmers think DFS are (perceived usefulness) and their confidence in using them (personal behavioral control) are key in influencing whether smallholder dairy farmers adopt digital financial services (DFS). Farmers are more likely to use DFS if they believe it's useful. Also, their confidence affects how they view the usefulness of DFS and what others think about using it. The analysis also found that perceived usefulness fully explains the link between confidence and intention to use DFS. This means efforts should focus on helping farmers see the value of DFS and feel more in control when using them.
- In Bungoma County, DFS use is shaped by factors like age, gender, household size, access to credit, trust, market conditions, and how aware farmers are about DFS. Older farmers and men are less likely to use DFS. On the other hand, having a bigger family, access to credit, and more knowledge about DFS increases the chances of using them. But informal market structures and low trust in digital systems still make adoption difficult.
- Different DFS combinations affect milk income and productivity differently. Some combinations lead to higher income, meaning non-users could benefit by adopting them. Others, like using only payment and credit services, could reduce income, showing that not all DFS combinations are helpful. Overall, though, using all five services together gives the biggest boost to both milk income and productivity.

Recommendations

To enhance adoption and impact:

- Introduce targeted education campaigns highlighting the benefits of DFS. This promotes perceived usefulness of DFS through targeted awareness campaigns, demonstrations and training showcasing how DFS improves income, access to markets, and ease of transaction
- Improve access to tailored credit facilities that meet the specific needs of smallholder dairy farmers.
- Establish inclusive community-based support networks that promote gender equity and peer learning. These networks should address demographic and social gaps by incorporating gender-sensitive approaches to DFS adoption and providing tailored onboarding support for older farmers.
- Build trust and formalize markets by partnering with trusted local institutions (e.g., cooperatives, SACCOs, agrovets) to introduce DFS products. Also, formalization of market structures, including use of e-receipts, contracts, and traceable transactions.
- Integrate DFS into extension services to include DFS modules in farmer field schools, cooperative training, and dairy sector forums**.**
- Support policy and ecosystem development to streamline DFS policies that favor rural and agricultural adoption

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Pathways for reviving Kitinda Dairies in Bungoma, Kenya

Practice Brief
FORQLAB Project 2024-11

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Marco Verschuur (ed)
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Introduction
Based on the food loss audits conducted by Master students, the scoping studies of Kitinda dairy cooperative, executed by Agriterra in December 2022, and interviews with the CEO, consecutive student teams of the Master Livestock Chain elaborated pathways for further development of Kitinda Dairies in Bungoma.

Kitinda Dairy Farmers Cooperative Society
Cooperative description (Agriterra 2023).
Kitinda Dairy Farmers Cooperative Society Limited is a farmer-owned dairy cooperative since 1957. It draws its membership from farmers spread across three sub-counties: Kabuchai, Kanduyi, and Webuye-West in Bungoma County. The enterprise is in Bungoma Town. The cooperative has 854 registered members-shareholders (68% women) of whom 709 are active.
Kitinda faced various challenges which led to its leasing to an investor and later led to its collapse, the premises were leased by an Indian for 14 years. The Indian left the premises in 2014 with 10M accrued debts for KRA, electricity, Cess (local tax), and County Bills. The farmers revived the society since they had high milk production but no market for their milk. During the 2019 AGM, a new board of directors was elected, which helped to stabilize the situation and started offsetting the debts but has not been able to clear the whole debt. The leadership of the society is currently in negotiations with the county Government of Bungoma to help them clear the remaining debts as their premises don't have power and they are using firewood to pasteurize the milk collected.
The cooperative owns two coolers with a capacity of 2000L and 3000L respectively which are currently not in use due to power outages. They own a 14.5 acre of land that they are planning to start a zero grazing unit and plant fodder crops on the part of the land. The office stands on two pieces of plot owned by the cooperative. Currently, they pasteurize between 600-2000L which is way below their capacity. They are planning to open 9 bulking centres in each zone aimed at increasing their volumes to 3000L. The cooperative produces mala and yogurt, 50-100L/day and 50L/day respectively then sells them locally. They also plan to sign a contract with a processor (to be identified) since they are now selling their milk locally.
The cooperative has in the past partnered with GIZ who has helped them in building the capacity of their farmers, developing the strategic plan (2022-2025), and the county government extension officers who train farmers.

Cooperative analysis

Two consecutive student groups made an analysis of Kitinda Dairies, using the value chain map (Figure 1) and problem tree (figures 2 and 3) as analysis tools.

Figure 1: Kitinda DFCS Value Chain with hotspots

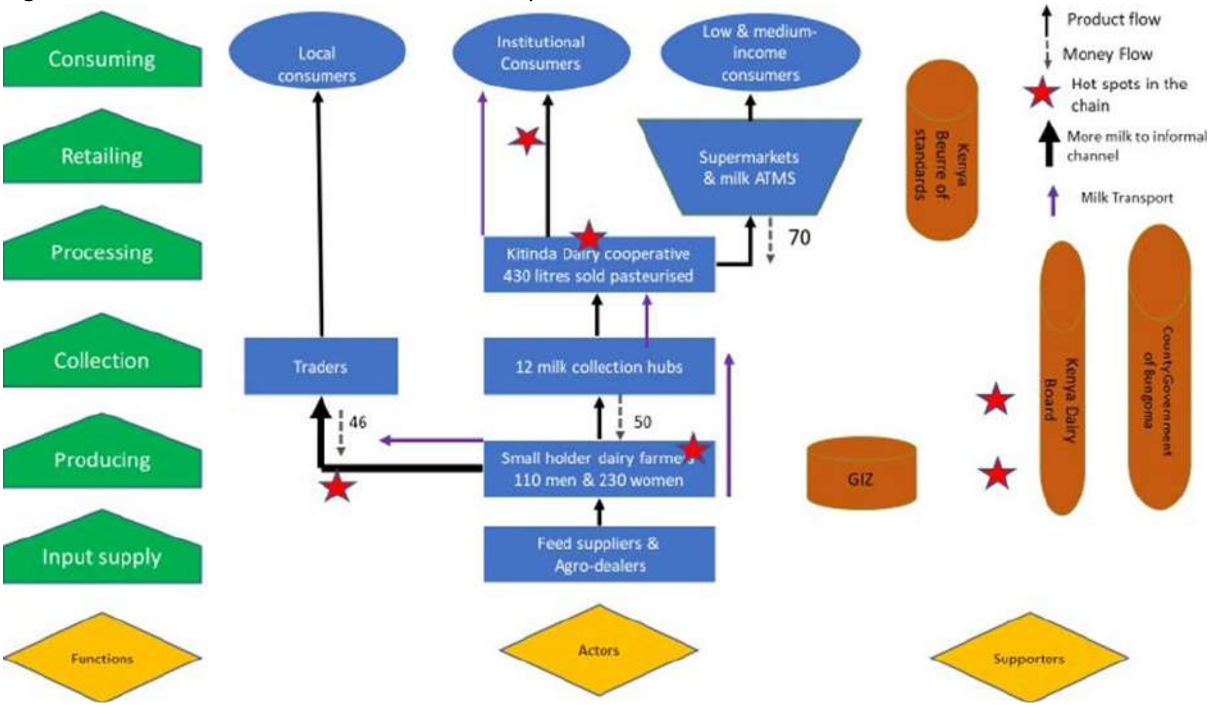
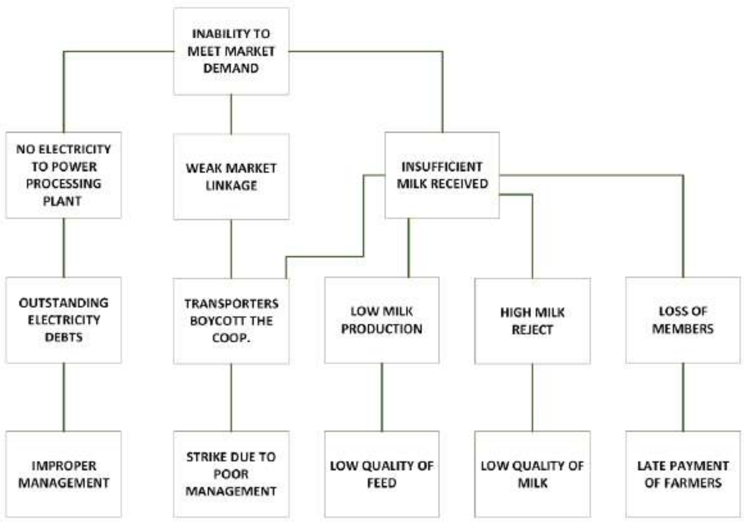


Figure 2: Problem Tree of Kitinda DFCS (group 2022-2023)

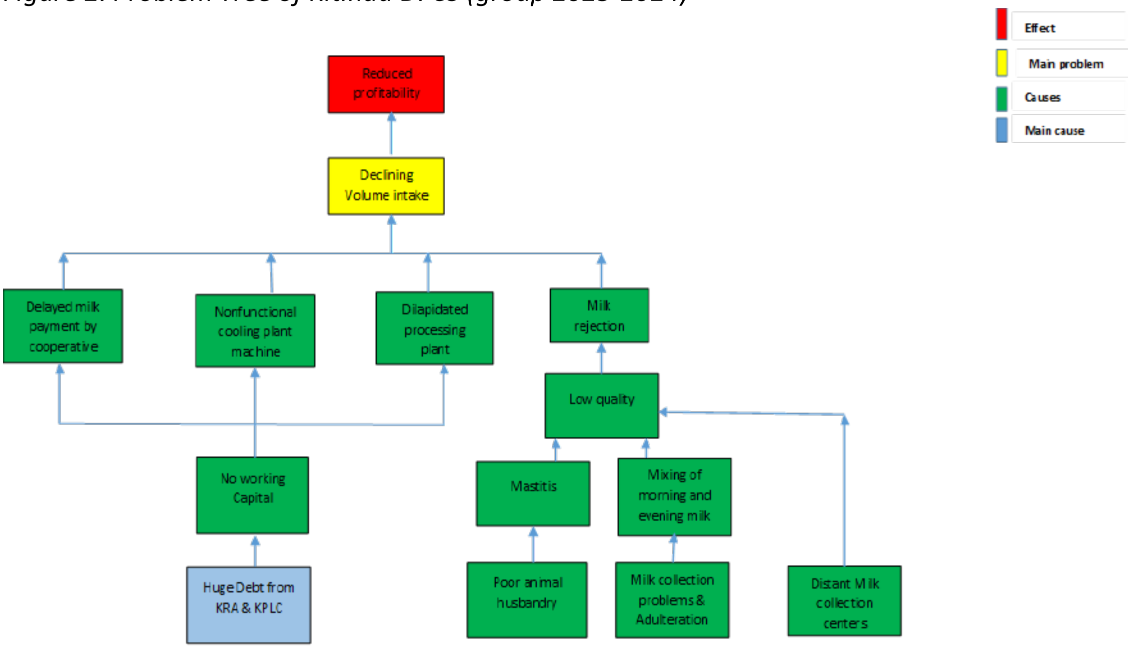


Student group 2022-2023 identified the main problem as **inability of the dairy cooperative to meet the market demand** in Bungoma, due to insufficient milk intake, not having electricity to power the plant, and weak market linkage. The cooperative can position itself to successfully meet market demands and expand its operations by increasing milk production, enhancing milk quality, utilizing its processing capacity, improving marketing and sales, and strengthening governance and management.

Student group 2023-2024 identified the **decline in milk intake** the main problem, which significantly diminishes the cooperative's profitability, hindering its growth. The principal factor contributing to this decline is a substantial debt accumulated during the previous terms. Addressing and clearing this debt is crucial to revive the cooperative's performance.

Other factors contributing to the reduction in milk intake include 1) delayed payments to farmers, prompting them to sell their milk through informal channels; 2) dysfunctional cooling plant, resulting from a lack of working capital; 3) broken down processing plant; and 4) milk rejection due to adds. Resolving these issues, particularly addressing the outstanding debt, is essential for Kitinda Dairy Cooperative to regain operational efficiency and financial viability.

Figure 2: Problem Tree of Kitinda DFCS (group 2023-2024)



PROPOSED INTERVENTIONS AND OUTCOMES

For Kitinda DFCS to have a sustainable business and meet market demands, the student team 2022-2023 formulated main results and interventions to ensure the improvement of Kitinda DFCS (Table 1), resulting in the proposed outcomes (Figure 4).

Figure 4: Proposed outcomes

Table 1: Proposed result and interventions

Results	Interventions
1. Clearing the outstanding debts	
2. Increase Milk Production	• Provide training and support to farmers on sustainable dairy farming practices, such as Good Dairy Husbandry practices and feed management. • Provide stainless milk cans to farmers to reduce milk loss. • Improve milk collection network that allows farmers to easily deliver their milk to the cooperative. • Capacity-building and training on fodder establishment and conservation

	• Strengthening the zero-grazing demonstration farm for fodder production.
3. Improve Milk Quality	• Train cooperative members on best practices for milk handling and storage to reduce contamination and loss. • Provide Kitinda DFCS with adequate testing equipment to assess milk quality and identify areas for improvement. • Develop and implement a quality assurance program to ensure compliance with national and international standards. • Provide incentives for farmers who produce high-quality milk, such as higher prices or bonuses.
4. Market Linkage to improve and strengthen market relationship	• Conduct market research to identify potential buyers and market trends. • Develop and implement a marketing plan to target potential buyers and increase sales. • Establish linkages with buyers to improve market access for cooperative members. • Training-of-trainers (ToT) on effective sales techniques and customer service • Rebranding of products and cooperative reputation
5. Strengthen Governance and Management	• Review and revise the cooperative's bylaws and policies to ensure they are aligned with best practices. • Develop and implement a communication strategy to improve member engagement and participation. • Provide access to affordable credit for members to by partnership with SACCO. • Train the cooperative board members in effective leadership and decision-making • Establish an internal monitoring and evaluation system to track progress against goals and adjust as necessary. • Establish a payment system for farmers where they get paid weekly for the milk delivered.

PROPOSED IMPACT PATHWAYS (student team 2023-2024)
Student team 2023-2024 elaborated an intervention pathway for Kitinda (figure 5).
Kitinda Cooperative is currently dealing with various challenges, including issues in management, sales, a declinein membership, milk quality, reduced revenue, substantial debt inherited from the previous facility occupant, and little support from the government. To tackle these challenges, the cooperative has identified working capital as a crucial solution.

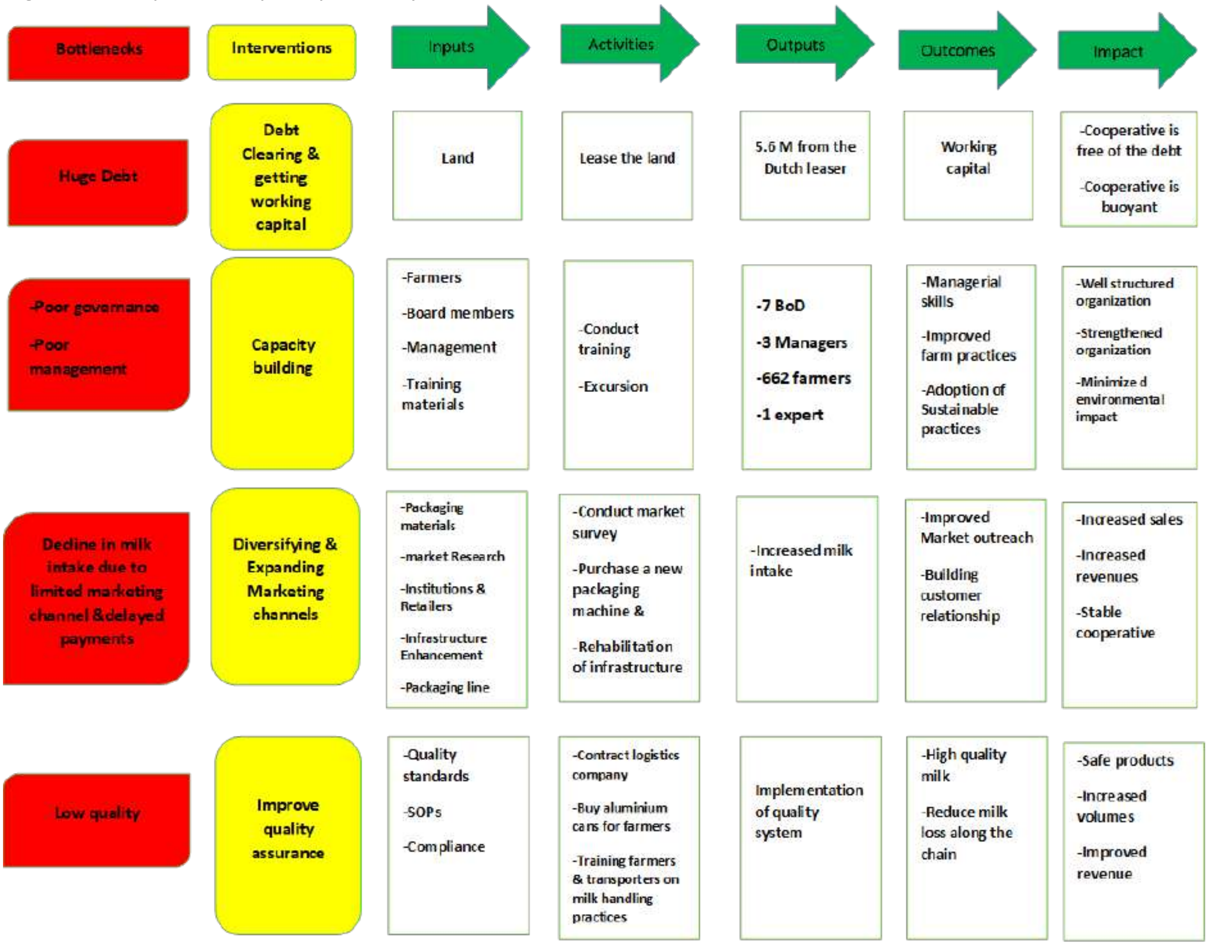
The initial step involves leasing the cooperative's fixed asset, which is 14 acres of land, to a forage producing firm for a period of ten years. This lease agreement provides capital and includes training for cooperative members inpasture management. The funds obtained from the lease will be utilised to clear the existing debt and serve as working capital for the cooperative.

Capacity building and development are key priorities. Board members and management will undergo regular training sessions three times a year, spaced every four months. Board members will visit Githunguri cooperative to learn about their management style and avoid repeating past mistakes. Additionally, cooperative members will receive periodic training on animal husbandry and milk handling.

The cooperative is grappling with delayed payments for delivered milk, partly due to heavy reliance on a single institutional consumer. To address this issue, the cooperative plans to employ a marketing officer to allow the cooperative to penetrate alternative markets. Hospitals and hotels will be targeted for bulk pasteurised milk, and new processing line will be acquired to sell packaged milk to supermarkets.

To minimise milk loss caused by rejection, the cooperative aims to improve milk quality brought to the market byimplementing corrective actions from the farm to the market. This improvement will be achieved through milking and milk handling training, transitioning from plastic to aluminium collection cans, and collaborating with a logistics company for milk transportation. Additionally, company drivers will undergo training in milk handling and rapid testing procedures.

Figure 5: Proposed impact pathway



The proposed interventions will change the current chain map of Kitinda cooperative (Figure 6). The improved chain map is based on available actors and supporters who play a role in the milk flow from farms to consumers.

Figure 6: The improved Kitinda DFCS Value Chain

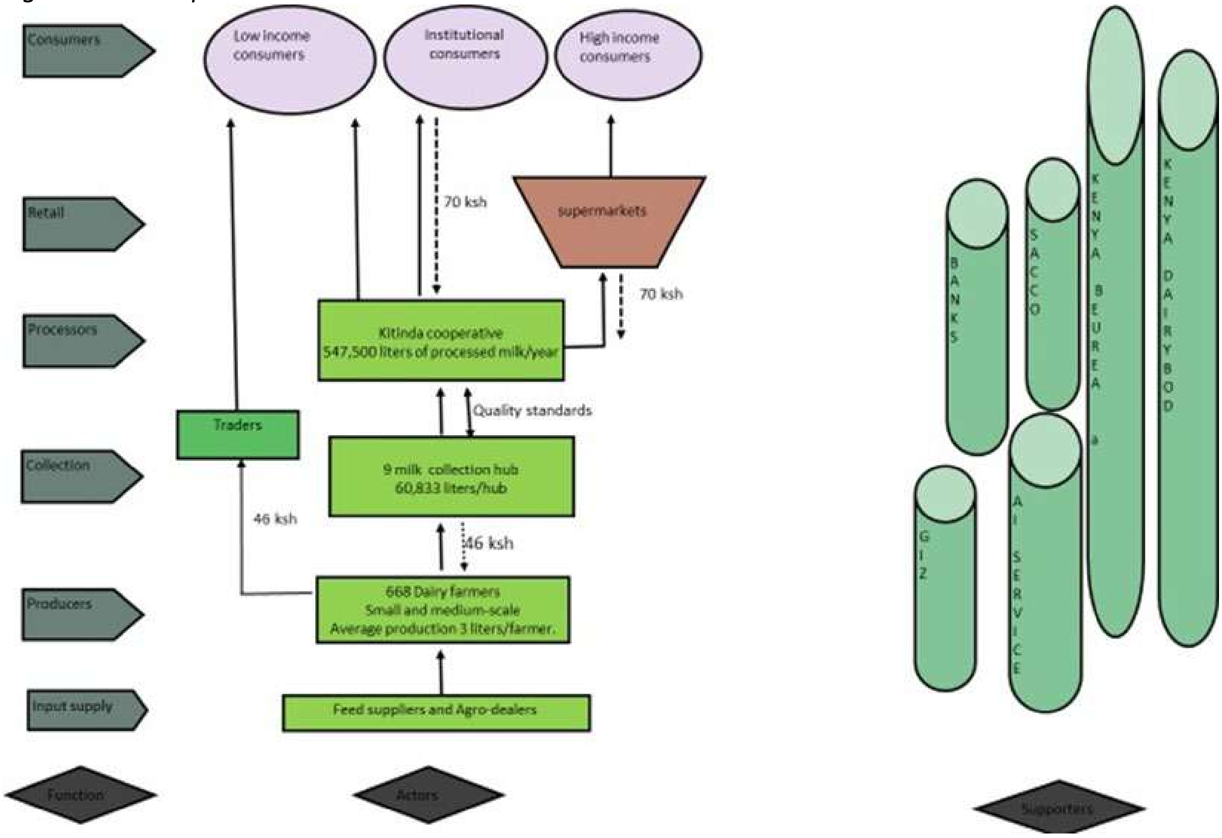


Table 5: Kitinda DFCS New Business Model Canvas (team 2022-2023)

Key partners	**Key activities**	**Value** propositions	**Customer relationship**	**Customer segment**
Kenya Bureau of standards (KeBS) Kenya dairy board (KDB) Kenyan agriculture livestock research organisation (KAIRLO) Ministry of agriculture, livestock and fisheries FORQLAB	Fresh milk collection Quality assessment Dairy products production (Mala and yogurt) Hygiene practices Quality management assistance	Plentiful acceptable fresh milk supply Quality Processed milk Assist smallholder dairy farmers' activity (training on good agriculture practices)	Price contract agreements Buyer-seller(local consumer) Dedicated personal assistance (SHDF)	Supermarkets Institutional market Niche market Segmented area (local consumer)
	Key resources		**Channels**	
	Milk collection point facilities Milk cans Production plants Qualified workers		Milk collection point Local store front Extension agents Veterinarian Fresh milk collector	

Cost structure	**Revenue streams**
Operational costs Raw material costs Transportation costs Purchasing costs	Sales of fresh milk collected from smallholder dairy farmers. Sales of dairy products

The future situation is elaborated in a Canvas Business Model (Table 5 en 6). It shows different elements of the cooperative business such as key activities, value proposition and value addition (yogurt, cheese), key partners they work with, key resources they need, channels, customer relationship, and customer segments.

Team 2023-2024 presents the triple Canvas business model, geared toward creating financial, social and environmental benefits. The success of each intervention is depending on clearing the debt owed by the cooperative. The **value proposition** is delivering high-quality milk products to consumers in collaboration with milk value chain shareholders. New market relationships will be built, existing relationships strengthened, and new alliances established. Logistics plays a significant role in milk quality because of the perishability of milk. There is an increased revenue stream because of reduced milk loss and increased milk intake volume, product diversification and new marketing channels. Some of the environmental benefits include the reduction of greenhouse gas emissions through the practice of climate-smart agriculture and efficient waste management.

Table 6: Kitinda DFCS New Business Model Canvas (team 2023-2024)

Key Partnerships	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• KALRO • GIZ • FORQLAB • KEBS • SACCO • KDB • Ministry of cooperative Dvp & market	• Milk processing • Dairy farming **Key Resources** • Partnership • Subsidies	• Offering high quality milk products	• Meetings • Telephones calls • Contracts / MoU • Visits **Channels** • Trucks • Motorcycles	• Hotels • Restaurants • Schools • Supermarkets
Cost Structure • wages, Feed, Animal health care • AI service, Energy & Water		**Revenue Streams** • Sales of Milk based products (raw milk, fermented milk & Yogurt) • Lease of land • Membership fees		

Supplies and out-sourcing	Production	Functional values	End of life	Use Phase
• By products • Packaging materials • Additives	• Milk production **Materials** • Semen, Vet drugs • Farm inputs, feeds • Milk test Kit	• 2000*70KES = 140,000 KES	• Good management of Manure **Distribution** • Wheel barrows • Bicycles	• Potential milk waste disposal by customers
Environmental impact • CFP from: -Motorcycles, machines -Manure -Enteric fermentation		**Environmental Benefits:** -Prevent milk waste -Crop residues, -use of manure to fertilize soil, -Integrated farming		

Social stakeholders Business model Canvas

Local community	Governance	Social value	Societal culture	End user
• Cooperative members participate in farming practices trainings	• Autonomous business **Employee** • Shared responsibility in decision making • Health & safety measure	• To consentaneously provide high quality Milk products	• Farmer group training program • Shared values • Open communication • Mutual support **Scale of outreach** • High end market	• Fat content • Protein • Vitamins & minerals
Social impact • Lactose intolerance • Heart disease • Type 2 diabetes • Alzheimer's disease • Tuberculosis		**Social Benefits:** -Community development -Empowerment of farmers -Milk waste reduction -Improved Living standards		

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Funmilayo Amole, Micheal Mgaya, Erikanobong Effiong, 2023. PROJECT PROPOSAL TO STRENGTHEN AND DEVELP KITINDA DFCS. Velp: APCM-LC assignment.

Julius Akhigbe, Hakizimana Casimir, Kamgishia Rwiza, Bethel Pendo, 2024. PROJECT PROPOSAL TO REVIVE MILK VALUE CHAIN AT KITINDA DAIRY COOPERATIVE IN BUNGOMA-KENYA. Velp: APCM-LC assignment.

Strengthening Climate Smart Dairy Development at Kaptama Dairies in Bungoma, Kenya

Practice Brief
FORQLAB Project 2024-12

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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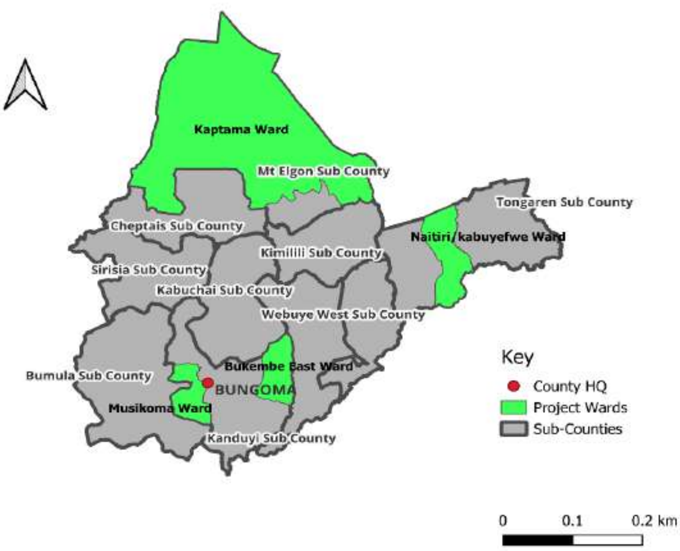
Introduction

Based on the food loss audits conducted by Master students, the scoping study Kaptama dairy cooperative, executed by Agriterra in December 2022, and interviews with the CEO, consecutive student teams of Master Livestock Chain elaborated pathways for further development of Kaptama Dairies in Bungoma.

Kaptama Dairy Farmers Cooperative Society

Cooperative description (Agriterra 2023).
Kaptama Farmers' Cooperative Society Limited is a dairy cooperative society which was started in 1958 as a multipurpose cooperative for dairy, beans, and maize value chains. It is located at Kaptama Market in Kaptama Ward, Mt. Elgon Subcounty. The current membership of the Kaptama dairy cooperative is 937 (513 Males, 424 Females, 385 youths) which is spread across Mt Elgon Sub County thus covering 8 Wards (six in Mt. Elgon and 2 in Saboti sub-county in Trans Nzoia County).

Figure 1: Map of Bungoma



The cooperative faced several challenges after inception which led the leadership to only focus on the dairy value chain (bulking milk and marketing it on behalf of their members) and not on Maize and Beans. They aimed to deliver the bulked milk to Kitinda Dairy Cooperative in Bungoma County which was fairly strong and well-structured. The partnership worked very well until challenges such as delayed payments set in alongside several other challenges that led to the collapse of Kaptama dairy cooperative. In 2013, farmers had very high production but had no market to sell their produce. They came together in search of a joint market, and this led to the revival of Society. The

Brookside processor was willing to collect milk from the farmers and gave them a cooler. They started with 400L/Day and increased to 1500L/day within a span of one month. The board members started 12 collection centres where farmers used to bulk their milk production and jointly sell to brookside until 2017. In 2018, the County Government donated a cooler of 3500L capacity to the cooperative that made Brookside repossess their cooler as Kaptama had their own enough cooling capacity. The Society bulks 3800L/Day but has the potential of bulking more than 4700L/day. Last year the society incurred losses since farmers produced a lot of milk (more than 5,200L/day) which was more than the cooling capacity. Currently, they have 20 collection centres where farmers bulk their milk, and transporters deliver it to the cooperative. Their main buyer is brookside and the local market.
In the recent past, the cooperative has attracted support from GIZ on farmers' capacity building, Kenya Climate Innovation Centre, RTI, and NARIGP project under the world bank. These partnerships have facilitated capacity building for the farmers, investment in ATMs which helps the society to pasteurize and sell the milk locally, pasteurizers, purchase of land, construction of the dairy hub where they will be processing milk, a chopping machine, molars machine for silage making, investment in A.1, milk testing equipment, agro-vet and 5 motorbikes.

Cooperative analysis

Two consecutive student groups made an analysis of Kitinda Dairies, using the value chain map (Figure 2) and problem tree (figures 3 and 4) as analysis tools.

Figure 2: Kaptama DFCS dairy value chain map

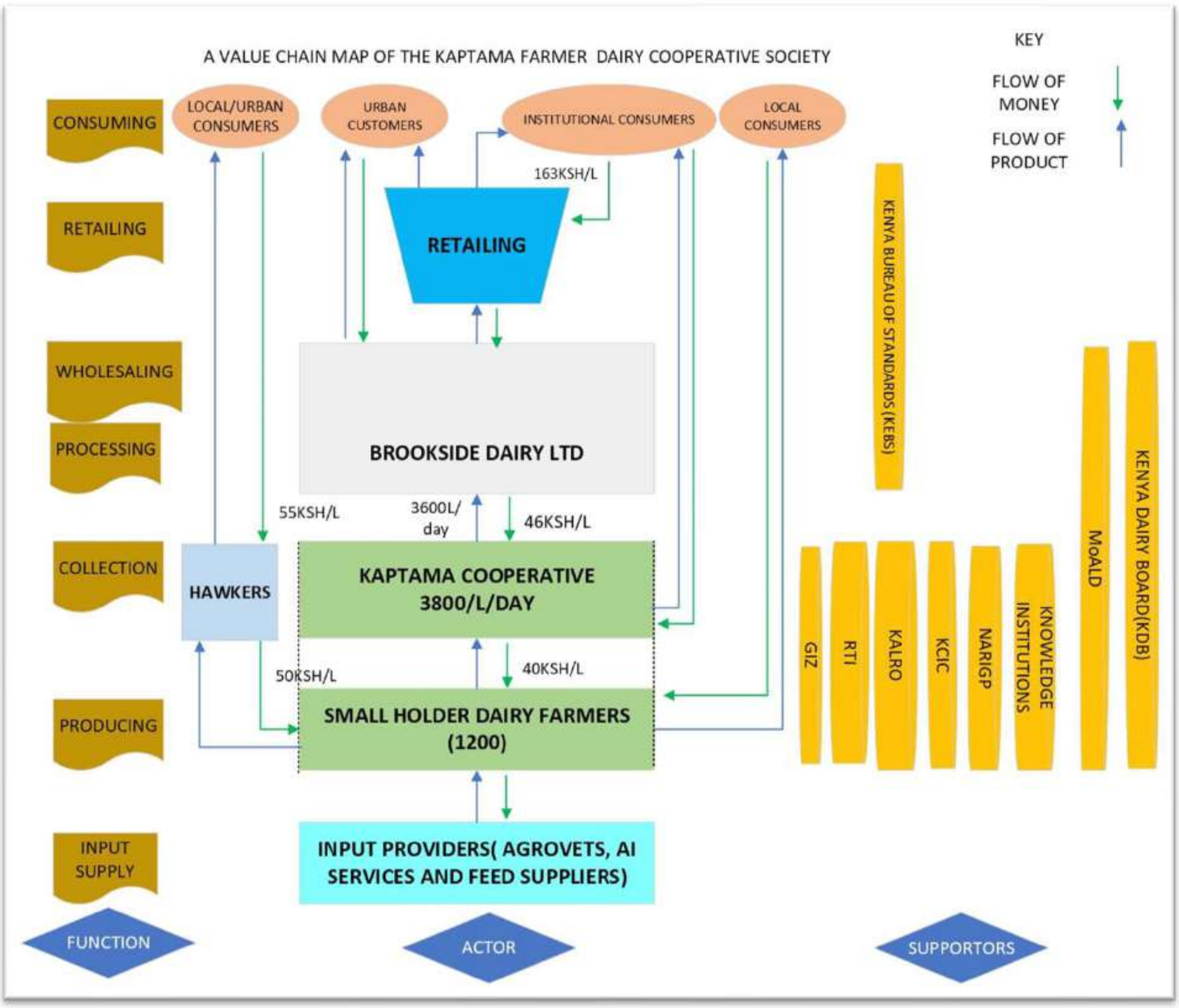


Figure 3: Problem Analysis Kaptama cooperative (student team 2022-2023)

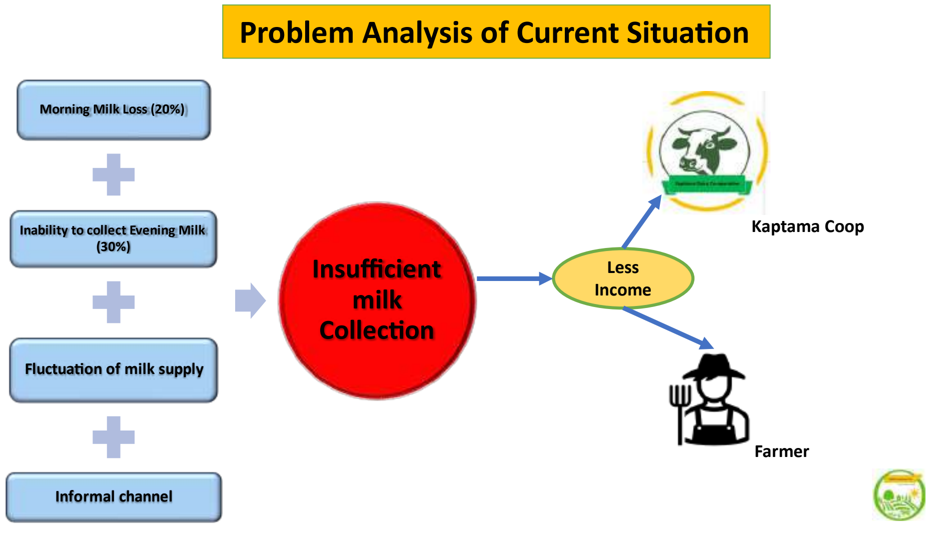
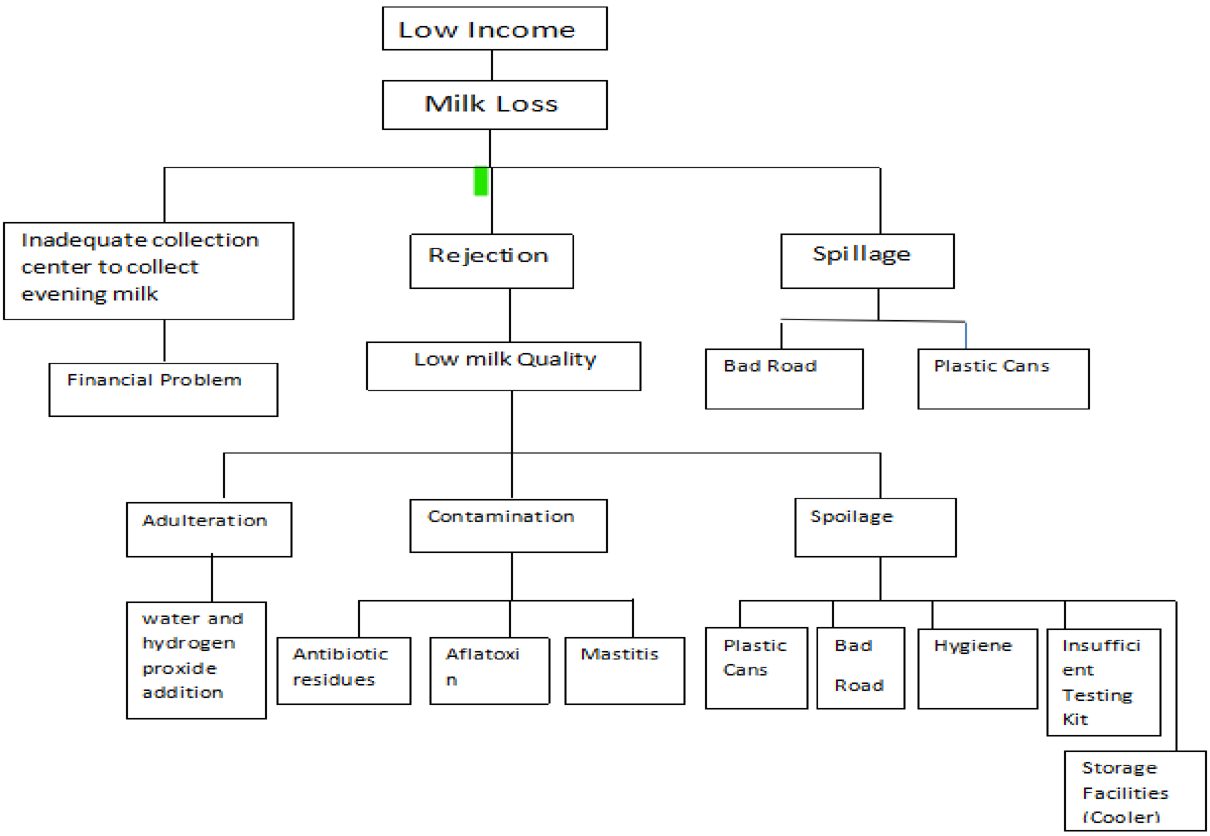


Figure 4: Problem Analysis Kaptama cooperative (student team 2023-2024)



Proposed Strategies (student team 2022-2023):
To fulfill the aim of the co-operative society the following strategies must be followed.
Business Strategies: Why will Coop go through the new business development?
- To strengthen their own business goal.
- To secure the income of famers and coop.

Marketing Strategies: How will Coop enter the dairy market?
- Development of new marketing path (broadcasting, campaign, discount etc.)
- Building the strong relationship (Trust) among the retailer and consumer.
- Taking the challenge to reach the goal in the competitive market.

Proposed interventions
Students proposed the following goals (Figure 5) and interventions (Table 1).

Figure 5: objectives of interventions

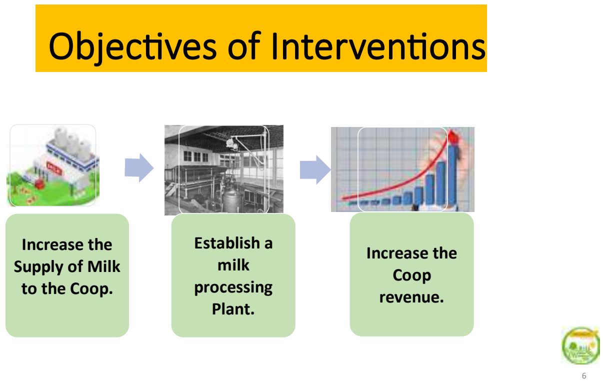


Table 1: Proposed interventions

Proposed Intervention	Conditions - comments
a) Provide Stainless-steel milk can:	Farmers must pay the milk can price by instalment regularly. The money will be deducted from their monthly payments, which will be controlled by the apps. Washing facilities will be provided for farmers at the collection point to secure the cleanness of the milk cans.
b) Installation of milk apps:	i. This project will assist the farmer payment system by the mobile apps. Farmers can enter their sold milk volume, check the receipt, and get the payment notification in their mobile. As a result, adulteration and milk loss will be resolved easily. ii. The quality checker will have the responsibilities to check the cleanliness of the milk cans every day. iii. Pay the milk according to quality rather than volume. As a result, farmers will be more aware about their milk quality.
c) Permanent collection (collection point, milk chiller and transport): (see figure 6)	i. Divide milk collection area (24 collection point) into six zones. ii. Zones will be two categories (far & near). iii. Build the permanent milk collection point in each zone. The farmers will bring their milk by their own arrangement (walking/ donkey cart/ try cycle). If it is too far, then co-operative could assist the transport. iv. Install one chiller in each zone depending on the usual milk volume. v. Make milk quality check facilities available in each milk collection point. vi. The cooler truck will transport the milk from the far zone to the Brookside processor company directly. It will reduce the transport cost. vii. Initially, 20% milk of current supplied milk will transport to the coop for further processing (Yogurt, Mala). viii. Install solar panel to secure the continues power supply at the collection point.
d) Training for Skilled Manpower:	i. **Training to Trainer:**

	In collaboration with the Government extension worker, AI technician, provide training to the Coop members about proper milk handling, cleaning of milk jar, AI technique, monitoring, milk processing etc. so that, in future they will be able to train to the farmers.
	ii. Training to farmer: ○ Train the farmers to use of mobiles apps (milk apps). ○ Train the farmers about fodder and forage preservation technique (silage & haylage). ○ Train to the farmer about heat detection of the cow, records keeping etc. ○ Provide yearly refreshment training to the trainer and farmers.
e) Development of own milk processing factory: (see logo and products in figure 7)	Milk production will increase steadily. The 20% of milk will go for the further processing by the Kaptama. The yogurt will be made from raw milk through sterilization, fermentation, and other steps. Commercial yogurt and mala business has low investment cost, small floor space, easy operation, and is profitable.
f) Development of market channel:	**a) Market Channel** It is the single most important factor for growing a business and generating sales. In a business plan, customer segmentation, market demand, product diversification and presentation, product advertisement, promotion etc. are essential to assess properly.
	b) Necessary Certification and Licenses i. **KEBS Certification: Criteria: Good quality Yogurt with** the recommended packaging. ii. **Business Permit.** iii. **Food Handling Certificate.** iv. **Food Hygiene Certificate.** **Certification Cost:** ○ Business Permit – KSH 5, 000 ○ KEBS certification – KSH 30, 000 ○ Food Hygiene Certificate – KSH 300 per year ○ Food Handling Certificate – KSH 600 valid for 6 months

Figure 7: Logo (a) and package specification (b)

Figure 6: Proposed milk collection routes

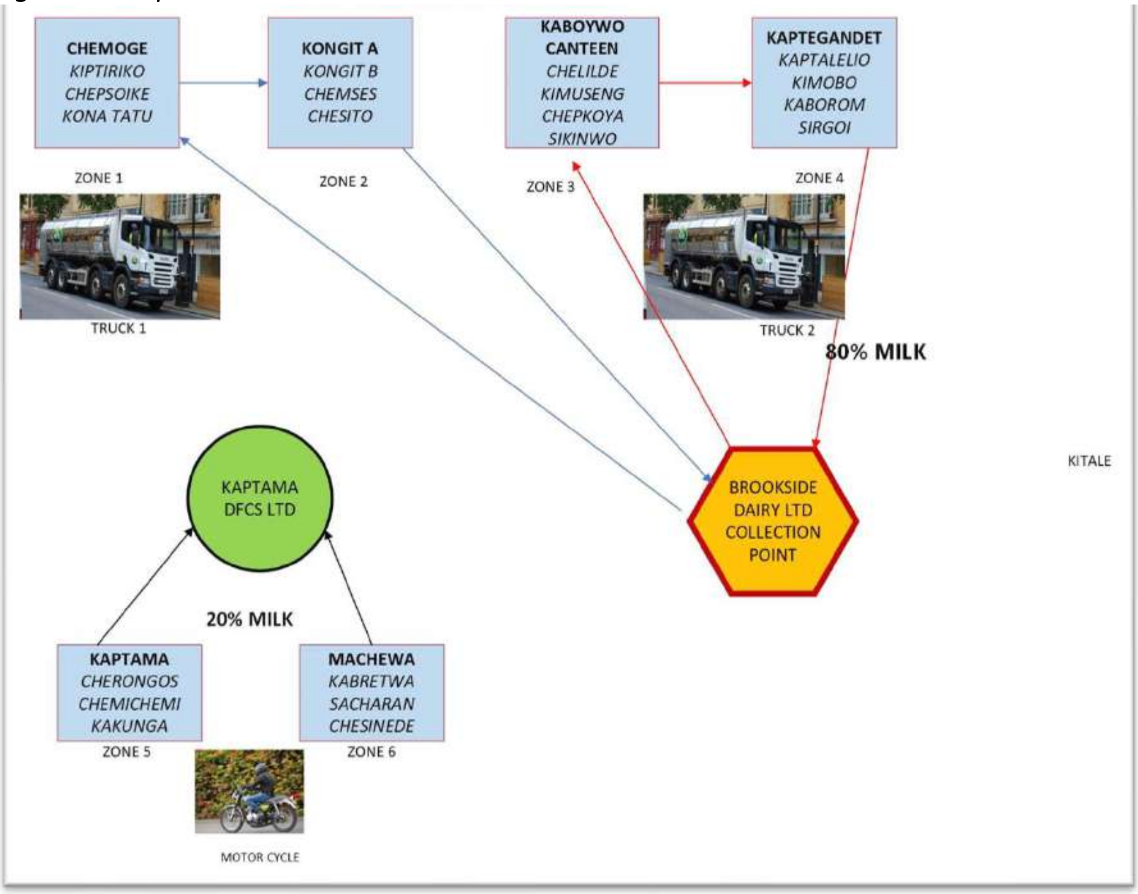
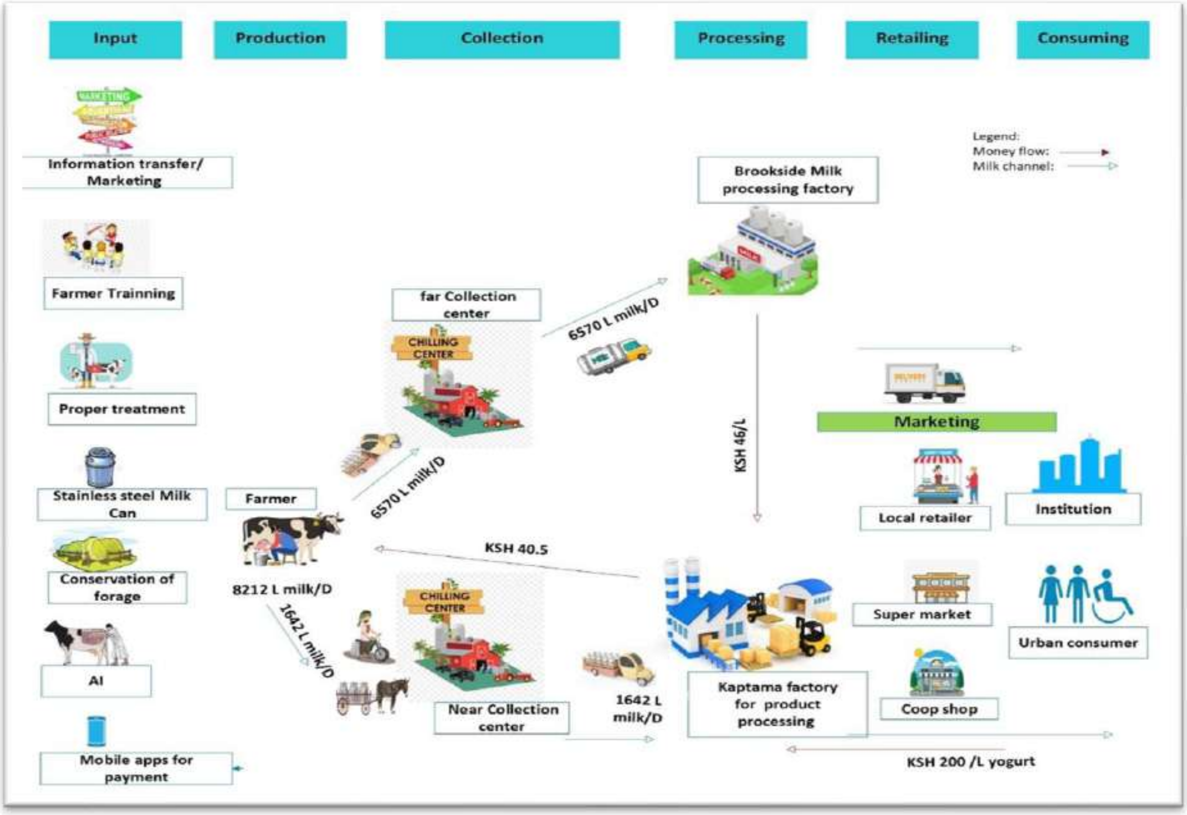


Table 2: Proposed interventions (per objective) (student team 2023-2024).

OBJECTIVE	INTERVENTIONS
Enhance milk quality and minimize milk wastage within the co-operative.	• Implement quality control measures at production and collection centres. • Procure 10 solar-powered mini-coolers (500L) at collection centres. • Procure 1300 certified aluminium metallic cans for distribution
Improve governance along the chain and at the cooperative level.	• Strengthening the capacity of the cooperative management • Organize field trip to and have an exchange program with Githunguri Cooperative • Procure 1 truck and 5 tricycles for milk transportation by 2026
Explore market opportunities	• Explore opportunities for evening milk • Train 100 women on value addition activities such as processing milk into yogurt and mala.

Figure 8: Proposed new chain



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Curriculum Development Using the Principles of Competency Based Training

Daan Westrik, Marjo Baeten

Practice Brief
FORQLAB Project 2024-04

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Curriculum development using the principles of competency-based training focusses on three different elements. These elements are the curriculum, the learning process, and the assessment.

The curriculum

Competency based training is students centred, task based and competency oriented.
To ensure the curriculum is task based different steps were used to design a curriculum based on the principles of competency-based training. These steps are the analysis of the labour market to identify job descriptions and professional tasks. Then selecting competencies for each professional task, selecting professional tasks and constructing the curriculum blueprint. And finally, the design of the assessments, the design of the learning task and formulating practicals. And lastly the selection of relevant theory.

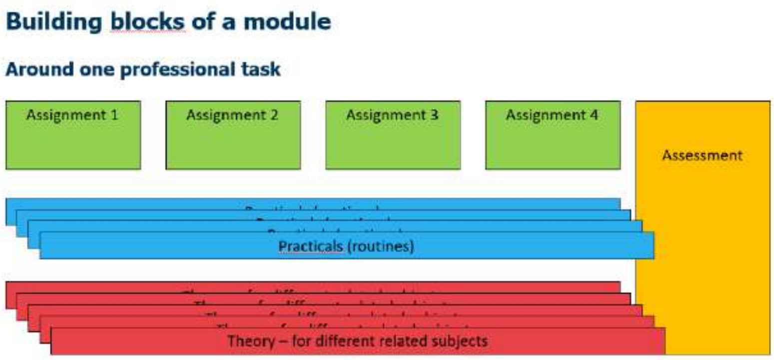

Figure 1: Building blocks of a module

Professional tasks

The purpose of the labour market analysis was to find the professional tasks for which the students need to be trained for. A detailed map of the value chain is made to provide information about the relevant jobs and professional tasks. This analysis resulted in a long list with different professional tasks.
Based on this longlist with professional tasks a selection is made. The selected professional tasks are relevant for the domain and the level of education the curriculum is aiming at.

Competencies

Because the curriculum will be competency oriented it's required to identify which competencies are needed to perform the different professional tasks. For this purpose, a list with ten generic competencies is used. Then, a limited number of professional tasks is selected by ensuring the ten different competencies are covered equally.

With the selected professional tasks, a curriculum blueprint is made. This curriculum blueprint presents which professional tasks is going to be trained in which part of the curriculum. For example, first year or second year, first semester or second semester. And the amount of study time available for each professional task is defined.

Curriculum development step by step:

1. Analysis of labour market
2. Identify Job descriptions
3. Identify Professional tasks

4. Assign competencies per professional task
5. Selection of professional tasks
6. Design curriculum blueprint

7. Develop assessments
8. Design learning tasks
9. Design practical's
10. Select relevant concepts or theory

11. Prepare Learning guides + Teaching guides

Figure 2: Steps for curriculum development

The amount of study time is related to the total amount of study time per academic year, and it includes all study activities of the student. Besides instruction in class also time required for individual study and assignments is included. Each professional task represents one module.

A curriculum based on tasks ensures that students gain experience and skills to perform professional tasks after graduation. Orientation on competencies ensure that students become flexible in performing related but different professional tasks making them flexible for a changing labour market.

The development of the different modules of the curriculum consists of the development of assessments, learning tasks and practicals. It also consists of selecting the relevant theory to be taught.

Assessments

Assessments will be based on the professional tasks and are a summative assessment to evaluate whether the student is able to execute the specific professional task. This assessment will therefore be performed at the end of a training period. For the development of the assessment a format is used.

Learning tasks

To ensure students gain experience in executing the professional task to be tested with the assessments a couple of learning tasks is developed. These learning tasks are assignments which by executing them provide experience in performing the professional task and the assessment.

Learning tasks consists preferably of the different steps needed to execute the professional task (and so the assessment). Which gives the students the possibility to gain routine in performing the task. Starting with learning tasks with a low level of complexity and finishing with learning tasks with a high level of complexity. At the same time starting with learning tasks with a low level of guidance and finishing with learning tasks with a high level of guidance.

Practicals and theory

The execution of learning tasks might require specific routines or skills. These skills will be trained in practicals. For a proper execution of learning tasks (and the assessment) knowledge might be required. The assessments and learning tasks will therefore direct which theory needs to be taught prior to or during the execution of learning tasks.

Four FORQLAB modules designed

Applying the above-described method for curriculum development 4 modules are developed to train students on the ability to contribute to food loss & waste reduction. Two modules are related to the dairy value chain and two modules are related to the avocado value chain.

For each module a specific professional task to be trained is chosen. For the two avocado modules these professional tasks are Marketing officer and Quality inspector. And for the dairy modules the chosen professional tasks are Extension and Quality control.

For each module a learning guide is designed. These learning guides contain a description of competencies to be trained, four or five learning tasks, a description of the assessment and a description of theory to be offered to support the execution of learning tasks and assessment.

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Adopting Organic Agriculture

100% ORGANIC

Healthy food, healthy consumer.

GITHUNGURI KENYA

ZERO FERTILIZER AND GMOS

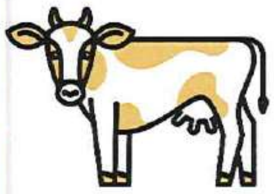
Farmers should use manure on their field. The grass should not be geneically modified.

ZERO GMOS

Make your goals measurable, achievable, and relevant to keep yourself motivated.

EXTENSIVE FARMING

The flocks should be raised primarily on grass, hay and silage.



ANIMAL HEALTH

Farmer use zero synthetic drugs

CH4

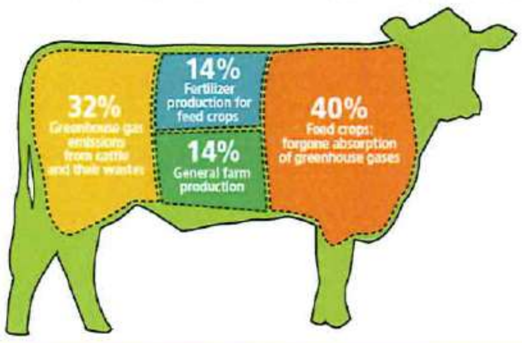
MANURE MANAGEMENT

One cow to one hecter of land to reduce the carbon footprint per amount of land used and provision of sufficient food for the cows

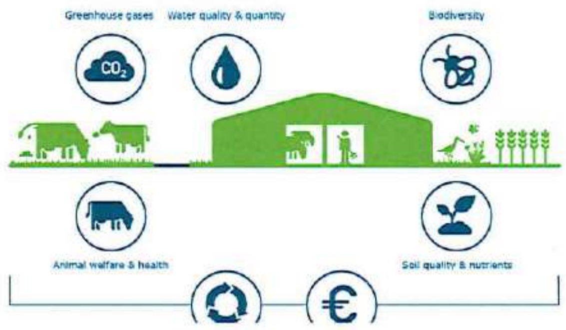
ANIMAL WELFARE

The herds will have better housing and spacing in the barn, more grazing hours and less stress.

Sources of Green House Gases



SUMMARY



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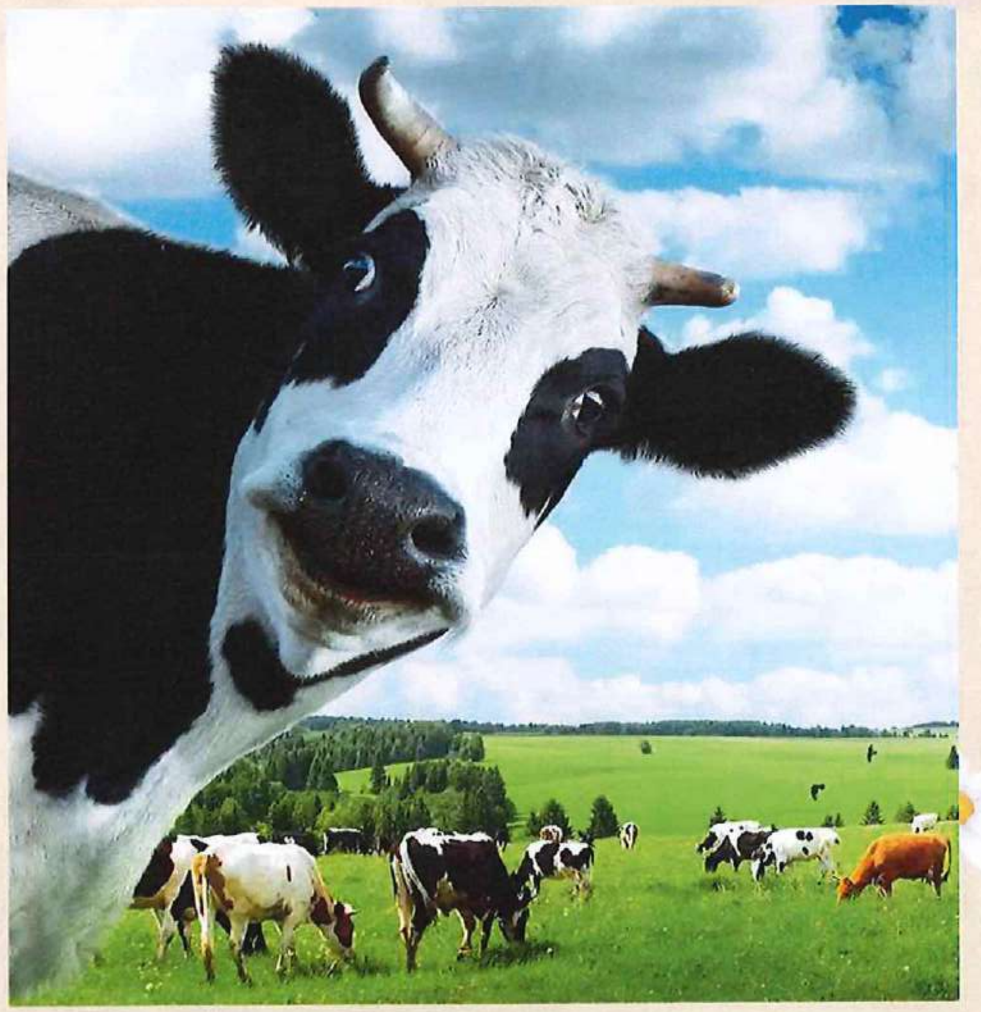

balance pasture grazing with certified organic feed

allow access to pasture and provide cunducive housing

ensure rotational grazing and diversity of forage crops

practise manure composting

use herbs and natural supplements for health management

TUFANYE PAMOJA

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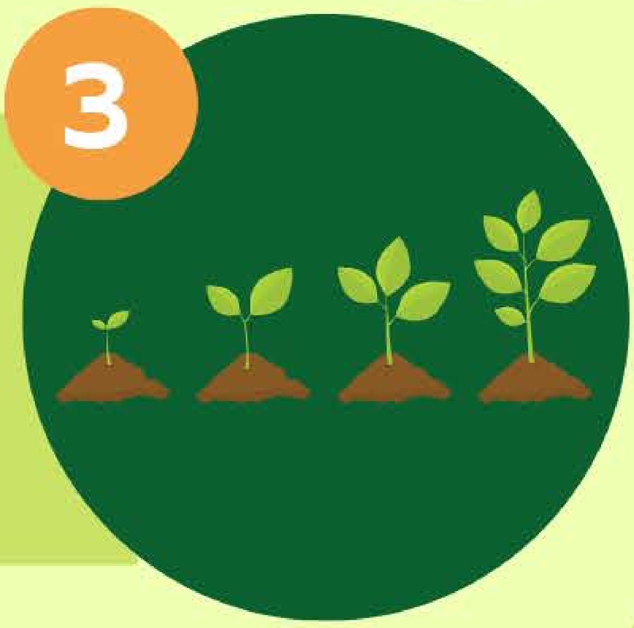
5 INTERVENTIONS FOR CLIMATE SMART DAIRY FARMING IN GITHUNGURI, KENYA

Manure Managment

Applying Biodigesters to capture Methane and Nitrous Oxide from Manure to produce Biogas, and the remaining bioslurry can be used as fertilizer.

Fodder Conservation

Silage, to ensure feed security and steady productivity in dry season, highly nutritious and reduce carbon emissions



Boundary Trees and Hedgerows

Provide wildlife habitat, control soil erosion and contribute to biodiversity by creating a diverse environment for plants, insects and birds.

High Yielding Cows

Improve Animal Husbandry to breed and raise highly productive dairy cows.
Friesian breed , Artificial insemination.

Water Managment

Applying Water Harvesting tanks to save the cost of pumping water from the well.

van hall larenstein
university of applied sciences

Maggie Sirati / Livestock APCM
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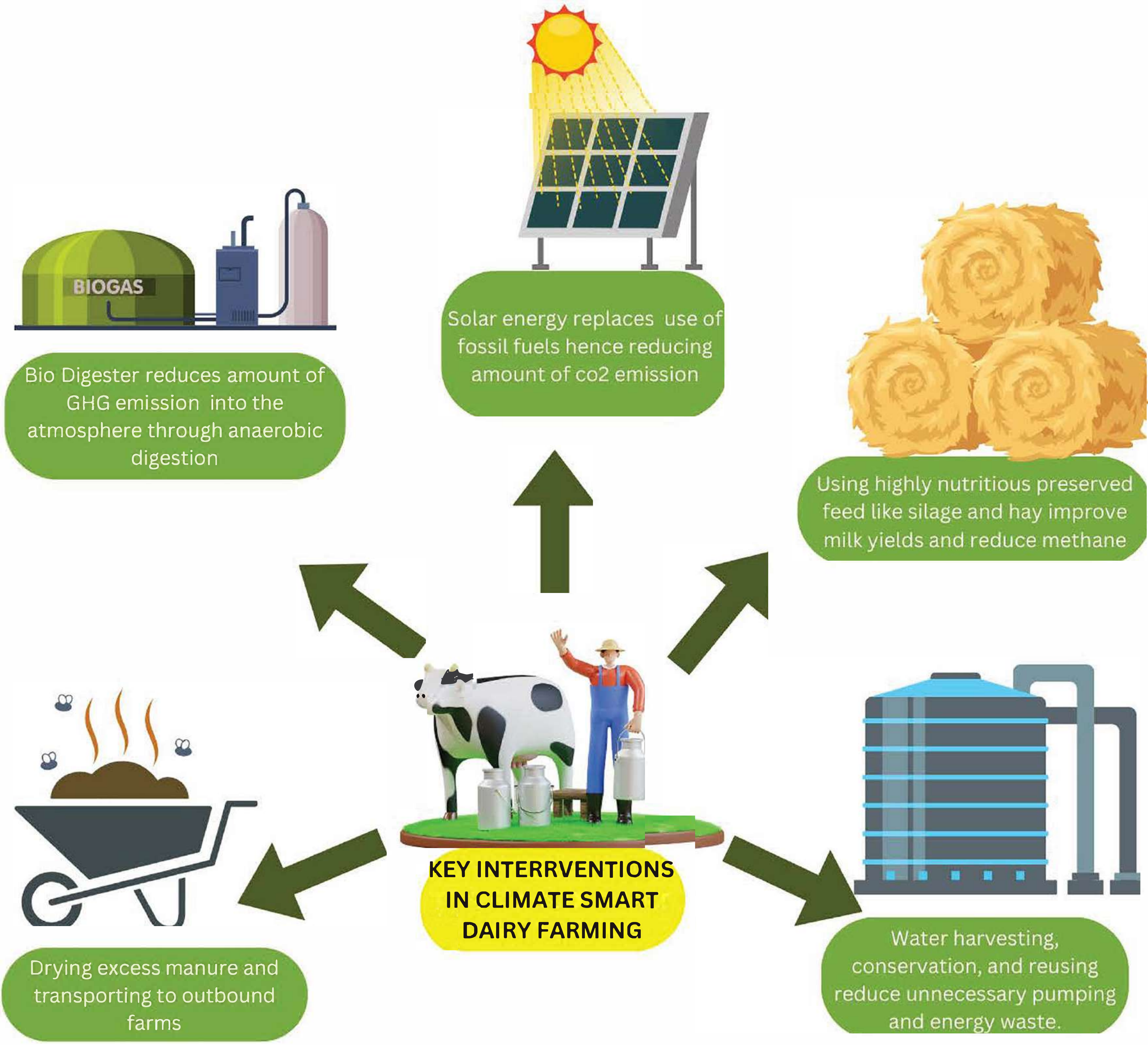
Interventions for Climate Smart Dairy Farming In Gighunguri-Kenya



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EMBRACING AGROECOLOGY IN DAIRY R DUCTION

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university of applied sciences

By Nana Takyi Broni

AGROECOLOGY

Agroecology in dairy farming is about working with nature, relying on natural processes to produce milk and dairy products with minimal chemical use, aiming for a sustainable and environmentally friendly approach.

Biodiversity Improvement 01

Integrate trees and shrubs into pasture areas to provide shade for livestock and improve biodiversity. Trees and shrubs aid in carbon sequestration reducing GHG in the atmosphere

Enhanced Nutrient Cycling 02

Boost soil health by recycling dairy manure as organic fertilizer, minimizing environmental impact and use of external input

Promotion of Synergy 03

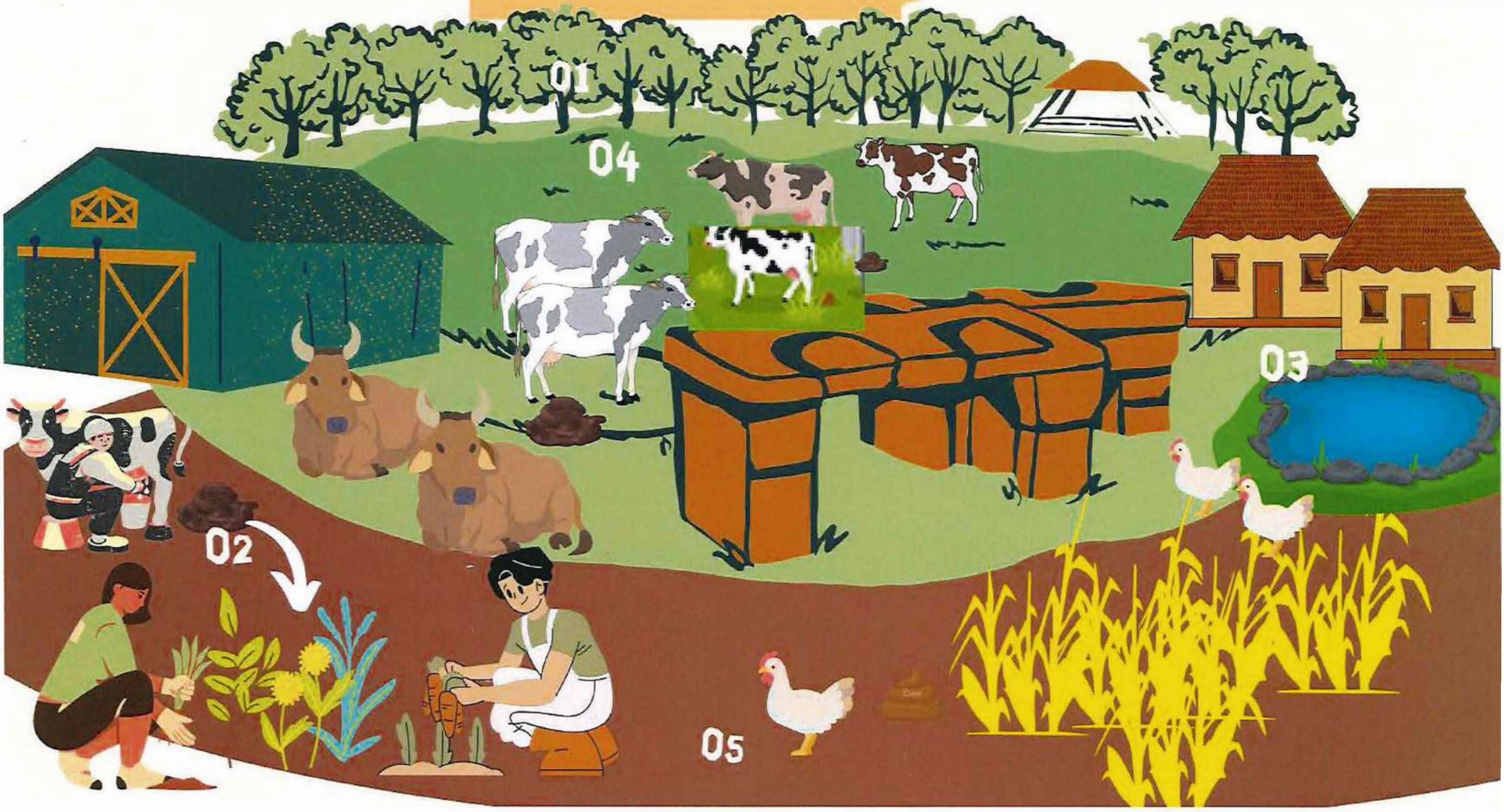
Integrate your Diary Farming with poultry, aquaculture, vegetables etc to enhance interaction and synergy within the agro-ecosystem

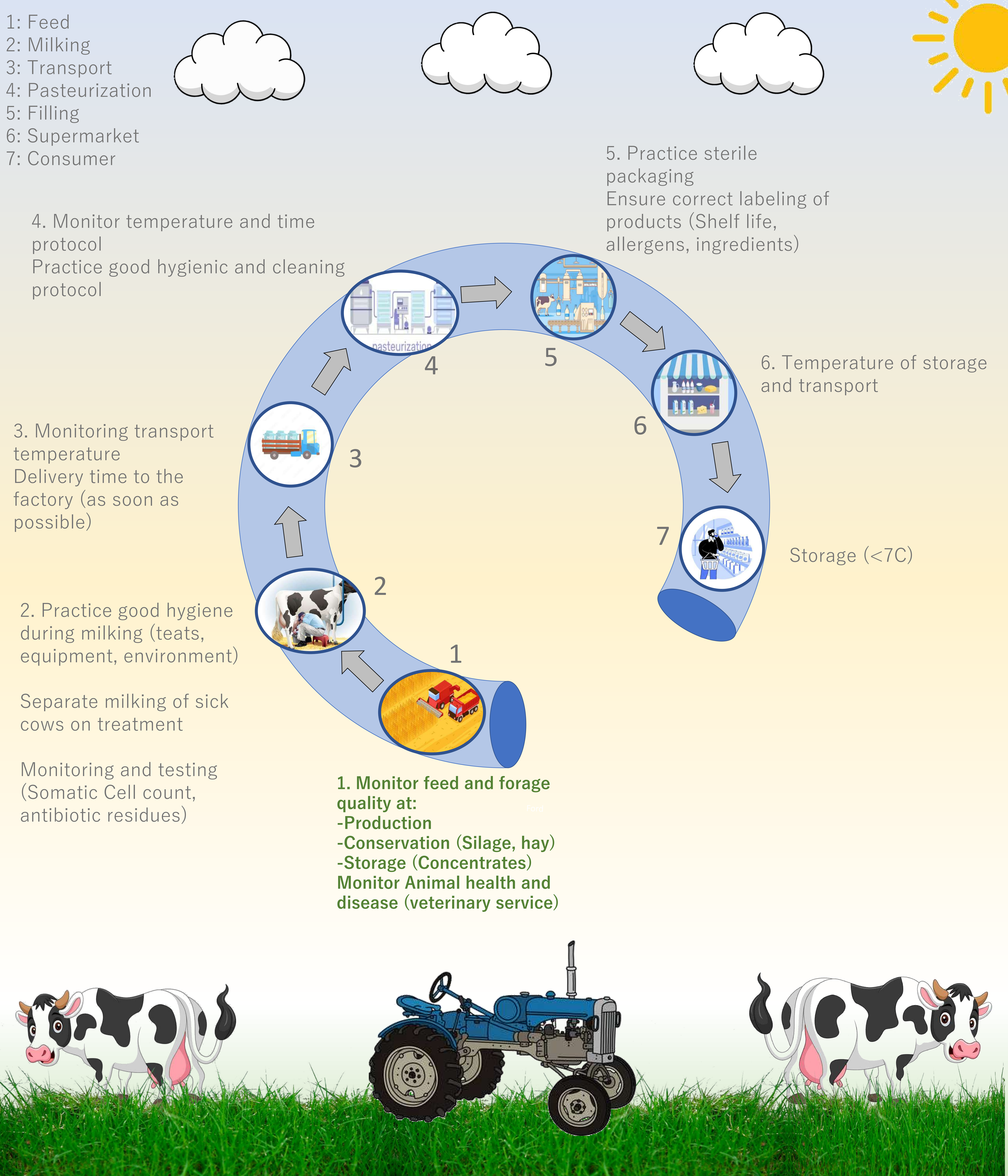
Reduced Methane Emissions 04

Grow pasture for a more balanced diet for livestock to contribute to lower methane production per unit of milk produced.

Diversification of Income Sources 05

Agroecology ensures diversification of farmi income portfolio through sale of forestry products, eggs, milk fish etc




1: Feed
2: Milking
3: Transport
4: Pasteurization
5: Filling
6: Supermarket
7: Consumer
4. Monitor temperature and time protocol
Practice good hygienic and cleaning protocol
5. Practice sterile packaging
Ensure correct labeling of products (Shelf life, allergens, ingredients)
pasteurization
4
5
6
6. Temperature of storage and transport
3. Monitoring transport temperature
Delivery time to the factory (as soon as possible)
3
7
Storage (<7C)
2
2. Practice good hygiene during milking (teats, equipment, environment)
Separate milking of sick cows on treatment
Monitoring and testing (Somatic Cell count, antibiotic residues)
1
1. Monitor feed and forage quality at:
-Production
-Conservation (Silage, hay)
-Storage (Concentrates)
Monitor Animal health and disease (veterinary service)

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