REPORT ON COST OF MILK PRODUCTION IN KENYA

By

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Background

The dairy industry in Kenya accounts for 14% and 4% of agricultural and total GDP, respectively. Cow milk represents 75% of annual milk production. (Food and Agriculture Organisation, 2024) while smallholder farmers produce 80% of the total milk (Rademaker et al., 2016). The milk yield gap in smallholder dairy production is estimated at between 39 and 49% of attainable yields, which limits the competitiveness of the country's dairy industry. Per capita milk consumption is 78 litres (Kenya National Bureau of Statistics, 2024), and growing demand against slowed production will likely result in a milk supply deficit. This may necessitate more imports to bridge the supply gap if production does not substantially increase. The high cost of milk production and price volatility, with a wide farm-to-retail price spread, are major concerns for the dairy industry.

The government's investment priorities in the dairy sector are outlined in the national strategies including the Kenya Dairy Master Plan (2010-2030), the Agricultural Sector Transformation and Growth Strategy (2019-2029), the Kenya Dairy Industry Sustainability Roadmap (2023-2032), and the Bottom-Up Economic Transformation Agenda (BETA) (2022-2027). These strategies aim to modernize the industry and position Kenya as a global dairy player by 2030. The priority interventions include improving feeding and breeding practices, lowering feed costs by promoting the cultivation of protein-rich crops, enhancing disease control, and investing in infrastructure such as milk coolers for milk supply chain development. The BETA strategy prioritizes the dairy sector and strives to increase productivity to reach 12 billion litres annually, improve milk quality and safety, support farmers and entrepreneurs, promote investment, invest in climate-smart agriculture, and improve access to markets. The government is also focusing on increasing the share of the formal milk market to 50%, which currently accounts for less than 20% of marketed milk, improving the quality of dairy exports, and establishing a minimum guaranteed price for milk.

The Kenya Dairy Board commissioned a study to estimate the cost of milk production in 2024 to inform policy and regulatory decisions, including interventions to ensure fair prices for both producers and consumers. This study aimed to document farm-level production costs, identify cost drivers, and propose interventions to enhance competitiveness. The study used a modified "typical" farm approach, where a typical farm in a county was identified by a team comprising experts and dairy producers and reflected the dominant production structure (in terms of scale and system) in the county. The study was conducted in 25 dairy-producing counties, and data for a typical farm in each county was collected through a focus group discussion (FGD) with a group of farmers and county livestock officers. In addition, data was collected from 30 model dairy farms (one or two in each county) through individual interviews. The model farms were identified collaboratively with the local dairy experts, including county livestock production officers, dairy cooperatives staff and the Kenya Dairy Board field staff.

Typical farms

The study findings indicate that a typical dairy farm had seven cattle on average, with 50% of the cattle being mature cows in all three production systems (zero, semi-zero and open grazing). About 75% of the cows were lactating. The average daily milk yield per cow was 9 litres, with farmers practising zero-grazing attaining a yield of 12.3 litres, which was 1.5 times higher than that in the semi-zero-grazing system (8.4 litres) and 1.7 times higher than for open grazers (7.2 litres). Friesian was the dominant breed in the dairy herd.

The average gross value of milk per litre of milk was KES 46[1]. The main milk buyers were dairy cooperatives, which offered an average of KES 43.5 per litre. Other buyers included consumers, processors and milk vendors.

The average total cost of producing a litre of milk was KES 36.2. The cost was KES 39.5 for zero grazing, 37.3 for semi-zero grazing and 24.5 for the open grazing system.

The average gross margin (GM) per litre of milk was KES 28.2, indicating that the dairy enterprise is generally profitable. The GM was lowest for zero grazers (KES 25.5) and about the same for semi-zero and open grazers (KES 30.6 vs 29.9). The average milk profit per litre was KES 10, with zero-grazers realizing KES 10, semi-zero grazers KES 8 and open grazers KES 14.

Using gross margin to total variable cost ratio (a measure of efficiency), results show that, on average, KES 2.4 was earned for every shilling spent on variable costs to produce one litre of milk. Open grazers had the highest return at KES 4.3, while zero grazers had the lowest at KES 1.2.

Feeds accounted for the largest share in the total cost of production (between 43 and 58%) across all three production systems, while labour followed closely at between 33 and 40%. For open grazers, maintaining animal health and breeding was a substantial component of total production cost (14.1%).

Model farms

Approximately half of the dairy herd in the model farms were cows, with 60%, 78% and 83% of the herd size lactating for semi-zero grazers, open grazers and zero grazers, respectively. The average milk yield per cow per day ranged from 14 to 23 litres, highest in zero-grazing and lowest in open-grazing farms.

The gross revenue per litre of milk ranged between KES 39.2 and KES 60, with the zero-grazing farms receiving the highest and the open-grazing farm receiving the lowest gross revenue.

[1] This is the average price per liter of milk by all buyers.

The average total cost of producing a litre of milk was KES 44.1 in zero grazing, KES 39.3 in semi-zero grazing and KES 24.1 in open grazing farms.

The GM per litre of milk was KES 22.8 for zero grazers, KES 34.9 for semi-zero grazers and KES 36.7 for open grazers. Profit per litre of milk was KES 5.2, 12.7 and 15 for zero, semi-zero and open grazers, respectively.

Open grazing model farms outperformed both zero grazing and semi-zero grazing model farms by generating KES 14.7 for every KES 1 spent on variable costs, indicating higher efficiency in the open grazing model farm.

Feeds and labour accounted for the largest share of the total cost of production across all the production systems. Feed costs comprised 65%, 54.2%, and 73.1% of total milk production costs in zero, semi-zero, and open grazing systems, while labour costs were highest in semi-zero grazing systems (33.0%) and lowest in open grazing systems (17.4%).

The above results indicate variations in the production costs and margins between model and typical farms. Relative to their counterparts in the typical farm category, zero and open grazing model farms had more lactating cows while semi-zero grazers had the same number. Milk yield was higher for model farms in all the production systems. The TVC were higher for zero and semi-zero grazing model farms but lower for model open grazers. Gross margin, milk profit and whole enterprise profit were higher for model semi-zero and open grazers but lower for model zero grazers. In terms of efficiency, model open grazers performed better while semi-zero grazers were less efficient. Model zero grazers had the same gross margin to TVC ratio as their typical farm counterparts.

The proposed farmgate pricing formula for raw milk in the draft "Dairy Industry (Pricing of Dairy Produce) Regulations, 2020" lacks flexibility, failing to address variables like fluctuating fuel costs and market dynamics that affect transport, chilling, and quality premiums. Additionally, the 5% management fee raises concern, as seen in sectors like tea where similar fees faced pushback. The formula's structure risks pushing farmers toward informal markets due to high transport costs, while possible regulatory overlap adds further complexity. We recommend a streamlined approach, using a base cost-plus-profit-margin model that offers a more adaptable formula. For instance, with an average production cost of KES 39.5 per litre, setting minimum prices at KES 45 for 15%, KES 47 for 20%, and KES 51 for 30% profit margins would allow market dynamics to create the relevant pricing signals in a sector where seasonality in supply leads to large price fluctuations.

Access to services and challenges in the dairy sector

Dairy farmers received extension services from various providers. Government extension service delivery has declined in the past five years due to insufficient funding and staffing. Hence, the private sector, cooperatives, agricultural projects and programs, and digital tools have become crucial for farmers' access to extension services.

Farmers valued livestock health management but struggled with the high costs of private livestock health services. Over 80% of farmers used AI services from county governments, cooperatives, and private practitioners. The county governments and cooperatives provide the service, but their services are unreliable. As a result, farmers rely mainly on the private sector to provide services. Low success rates attributed to low-quality semen, improper timing of the cow's heat cycle and general lack of good dairy cow management are major challenges to farmers.

Poor feed quality, especially for commercial feeds, was a major constraint in dairy production; monitoring feed quality in the market has been inadequate. Farmers rely on indicators like milk production, cow appearance, and feed packaging to judge feed quality. Inconsistent feed quality affects milk production and animal health. Despite receiving training, few farmers adopted optimal cow-feeding practices, citing cost as a key limitation.

Farmers in the zero-grazing production system reported practising feed preservation primarily by making silage and hay and preserving maize stovers and bean residues. In open grazing and semi-zero grazing systems, farmers rotate animals in paddocks to ensure the pasture grass regrows. Model farmers mentioned purchasing hay and silage at lower prices during the harvest season for later use. The adoption rate of feed preservation remains low due to various resource-related challenges, including a lack of technical skills and knowledge (e.g. proper ways for feed preservation to avoid rotting and aflatoxin contamination during silage making). Other challenges include the high cost of feed components, unavailability of good quality components (raw materials), lack of infrastructure (equipment required, e.g. feed mixing mills), and competition for land between food crops and animal feed crop production.

Manual labour was used heavily in dairy production due to a lack of awareness of and the high costs of labour-saving technologies.

Dairy farmers faced various other challenges such as fluctuating milk prices, lack of transparency in milk pricing and payout by cooperatives, high cost of zero-grazing units and other necessary infrastructure. All these impact milk yield and income.

Recommendations

Although zero grazing is encouraged due to declining land sizes, the study findings show that the system has the highest costs and lowest returns, driven mainly by high cost of feed. To improve returns in dairy farming, the following actions are critical:

a. Reduce the cost of feed. This can be achieved through several actions, including lowering taxes on feeds, raw materials, and equipment for feed formulation and manufacturing, promoting feed formulation by cooperatives and farmers, encouraging high-quality fodder production and utilization, and on-farm feed preservation.

b. Enhance monitoring and enforcement of the quality of feeds and raw materials in the market.

c. Promote the adoption of cattle breeds that are more adaptable to local conditions and have better feed conversion efficiency. This can be done by enhancing AI services through collaboration between the government and private service providers and educating farmers about alternative breeds that may be better than the commonly kept Friesian.

d. Information and training of farmers on dairy herd management. Essential practices include culling, heat detection, nutrition and health management. For example, dairy cows should be culled after 4 to 6 lactations (or about 6 to 8 years of age) when milk production declines significantly. These management practices may require capital input but will result in improved milk yield and farmer return.

e. Enhance transparency in milk pricing and timeliness of payment to farmers by cooperatives and processors.

These actions require collaboration and partnership among various actors in the dairy value chain, including the government, aggregators (cooperatives), processors, livestock health service providers and farmers.

1 Introduction

1.1 Background

The dairy industry accounts for 14% of Kenya's agricultural GDP, which equals about 4% of total GDP (Nguli & Kyule, 2020; Njagi, 2022). The industry is dominated by cow milk, which accounts for about 75% of total milk production. (Food and Agriculture Organisation, 2024). Besides, the sector is essential due to its potential to increase farmer incomes, create jobs in logistics and value addition along the value chain, and meet household food security requirements. Milk, excluding butter, accounts for 7% of calories consumed (Kenya National Bureau of Statistics, 2024) and hence it is a crucial source of calories.

Kenya's per capita milk consumption is estimated at 78 litres per annum, and the demand is expected to grow as the population increases. On the production side, more than five million dairy cattle produce an estimated five billion litres of milk annually. Milk is primarily produced by smallholder dairy farmers who produce 80% of domestic milk in Kenya (Kenya National Dairy Master Plan 2010-2030) (Republic of Kenya, 2010). The dairy sector is estimated to have 1.8 million smallholder farmers (about 80% of producers), who account for 56% of total output. The remaining 44% of milk output comes from large commercial farmers (Njagi, 2022; Climate Focus, 2018).

Dairy cattle in Kenya consist of exotic breeds, local breeds, and crosses between exotic and local breeds. The cattle are reared under three main production systems - zero grazing, semi-zero grazing and open grazing. The average milk yield ranges between 6 and 8 litres per cow per day but varies across production systems (Tegemeo Institute and Kenya Dairy Board, 2021; Tegemeo Institute and Kenya Dairy Board, 2016). The highest milk yield is attained in intensive production systems, which also incur the highest cost in production. Kenya's average milk yield is generally low; the milk yield gap in smallholder dairy production is estimated at between 39 and 49% of attainable yields (Graham et al., 2024).

The country targets to be a net exporter of milk by 2030 (Ministry of Agriculture and Livestock Development, 2010). However, this goal is not feasible at the current levels of productivity. For example, the country would have to more than double the herd size by 2030 just to meet domestic demand (Climate Focus, 2018). Hence, raising per-cow productivity and investing in public goods to enhance value chain efficiency is the optimal strategy. This has led the government to prioritise the dairy industry in national strategy and plans such as the Kenya Dairy Master Plan (2010-2030), Agricultural Sector Transformation and Growth Strategy (ASTGS) (2019-2029), the Medium-Term Plan IV (2023-2027), Kenya Dairy Industry Sustainability Roadmap (2023-2032) and the Bottom-Up Economic Transformation Agenda (BETA). Critical interventions planned include improving feeding and breeding practices; reducing cost of feed concentrates by investing in protein-rich crops such as sunflower, cotton and canola whose by-products are used in the manufacture of concentrate feeds. Specifically, the BETA strategy prioritizes the dairy sector and strives to increase productivity to reach 12 billion litres of milk annually, improve milk quality and safety, support farmers and

entrepreneurs, promote investment, invest in climate-smart agriculture and improve access to markets by exporting 1 billion litres per annum. Additionally, the government is focusing on increasing the share of the formal milk market to 50% (which currently accounts for less than 20% of marketed milk), improving the quality of dairy exports and establishing a minimum guaranteed price for milk. Other interventions include enhancing disease control and animal husbandry practices by improving farmer extension services, increasing the supply of relevant rural infrastructure such as milk coolers, and increasing the quality and range of exportable dairy products.

Figure 1 shows trends in milk production and its marketing through formal milk markets, which account for about 20% of all marketed milk. Milk production was low in 2019 and 2020, recovered following the COVID-19 pandemic shock, but declined slightly in 2022 due to drought. At the height of the drought in 2022, the share of milk marketed and processed in formal markets dropped but rose in 2023.

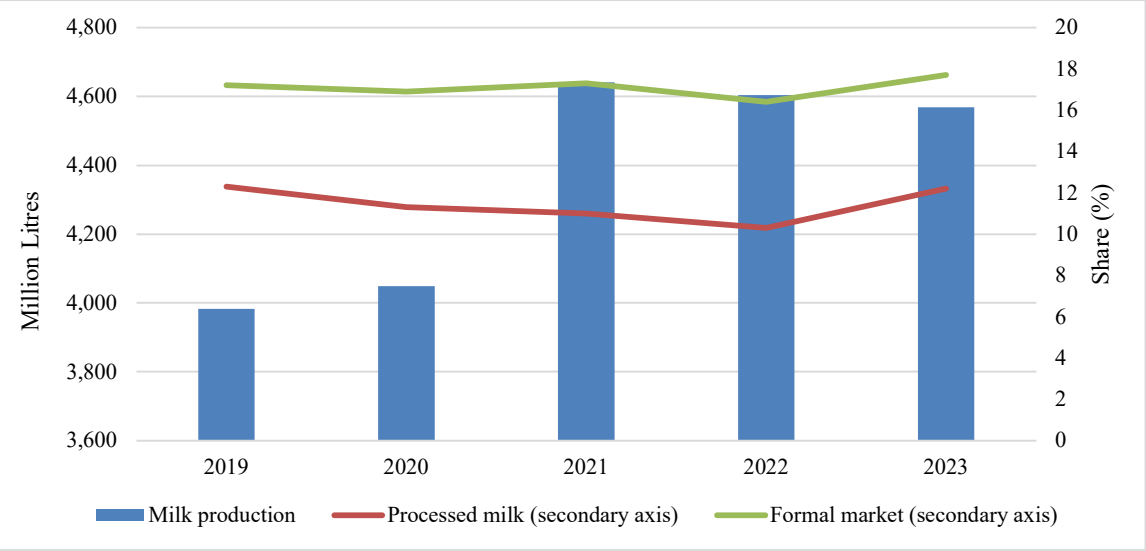

Figure 1: Milk production and marketing in formal markets

Source: KNBS, 2024

Kenya's huge dairy market presents producers with a significant market opportunity. However, this opportunity can only be realized by ensuring the competitiveness of production and profitability for producers. At the heart of this would be implementing strategies to improve production, productivity and profitability of producers while ensuring value chain efficiency. The profitability of dairy production is adversely affected by the high cost of milk production and volatility in producer prices. These prices have improved over the past five years, although the gap between farm gate and retail packaged milk remains large (Figure 2).

Actors must get a fair return to the value added to attain value chain efficiency. Previous studies on the cost of production in 2016 and 2021 established that dairy farmers spent more on animal feeds and made meagre profits from sale of milk. While higher producer prices of milk might increase the profitability of dairy farmers, these studies established that improving farm

productivity and economic efficiency were the most suitable options for enhancing the sustainability of dairy farming in Kenya. An increase in producer prices raises consumer prices and depresses demand for milk. Furthermore, higher consumer prices for locally produced milk make it unattractive compared to cheaper imported milk, especially from neighbouring countries such as Uganda.

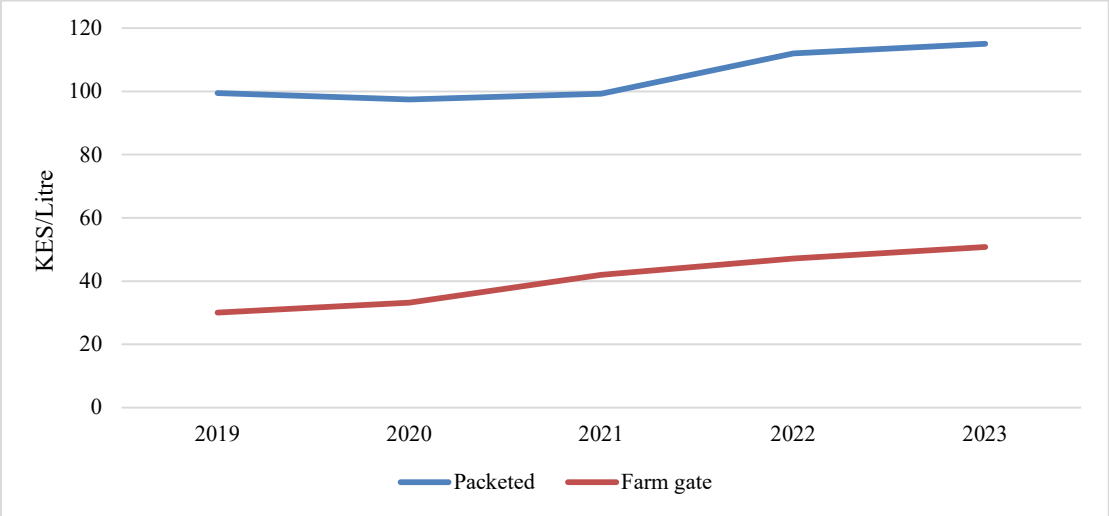

Figure 2: Milk prices at farmgate and retail levels

Source: KNBS, 2024

The Kenya Dairy Board is mandated to regulate, develop and promote the Kenyan dairy industry. In fulfilling this mandate, the Board advises on policy and regulatory decisions. Hence, the Board commissioned a study on the cost of milk production for 2024. This study is critical in generating data and evidence that can guide key regulatory decisions, such as setting a floor price for milk in the country. The study also explores options for enhancing efficiency in the dairy value chain and ensuring favourable prices for both producers and consumers of milk.

This study is essential given increasing concerns about farm gate milk prices. On one hand, dairy farmers contend that farm gate prices do not account for the costs they incur to produce milk and hence demand higher prices. Farmers' view is that milk processors underpay them, and the prices they receive are not sufficient to cover their production costs. On the other hand, processors indicate that the producer price of milk in Kenya is too high, especially compared to milk produced in neighbouring countries, which adversely affects the competitiveness of locally produced milk.

Similar to the studies conducted in 2016 and 2021, this study was carried out to inform the Board on the current cost drivers and what can be done in accordance with the Dairy Industry (Pricing of Dairy Produce) Regulations 2021, which aim to ensure primary producers receive guaranteed minimum producer prices for milk.

1.2 Study Objectives

The purpose of this study is to document the farm-level cost of milk production in Kenya and to assess the profitability of dairy production. The specific objectives are to:

a. Estimate the cost of farm-level milk production in Kenya across selected counties with varying production systems, scale and commercialization levels

b. Establish the key drivers of farm-level cost of milk production and their relative importance

c. Recommend potential interventions to manage the farm-level cost of milk production and ensure competitiveness

d. Propose a formula based on the cost of milk production and other relevant variables for the computation of minimum producer prices of milk

e. Recommend the minimum producer prices for raw milk and other areas of interventions based on the findings of the study

2 Methodology

2.1 Study areas

This study was conducted in 25 milk-producing counties in Kenya (Figure 3 and Table 1). The counties were selected based on the agroecological zones in the country and whether the counties could be classified as high, medium, or low milk-producing areas. In each county, the following considerations were made in identifying the locations from which farmers were sampled:

a) Systems of milk production (zero grazing, semi-zero grazing and open grazing)

b) Scales of milk production, namely small, medium and large

c) Typical and commercial/model dairy farms

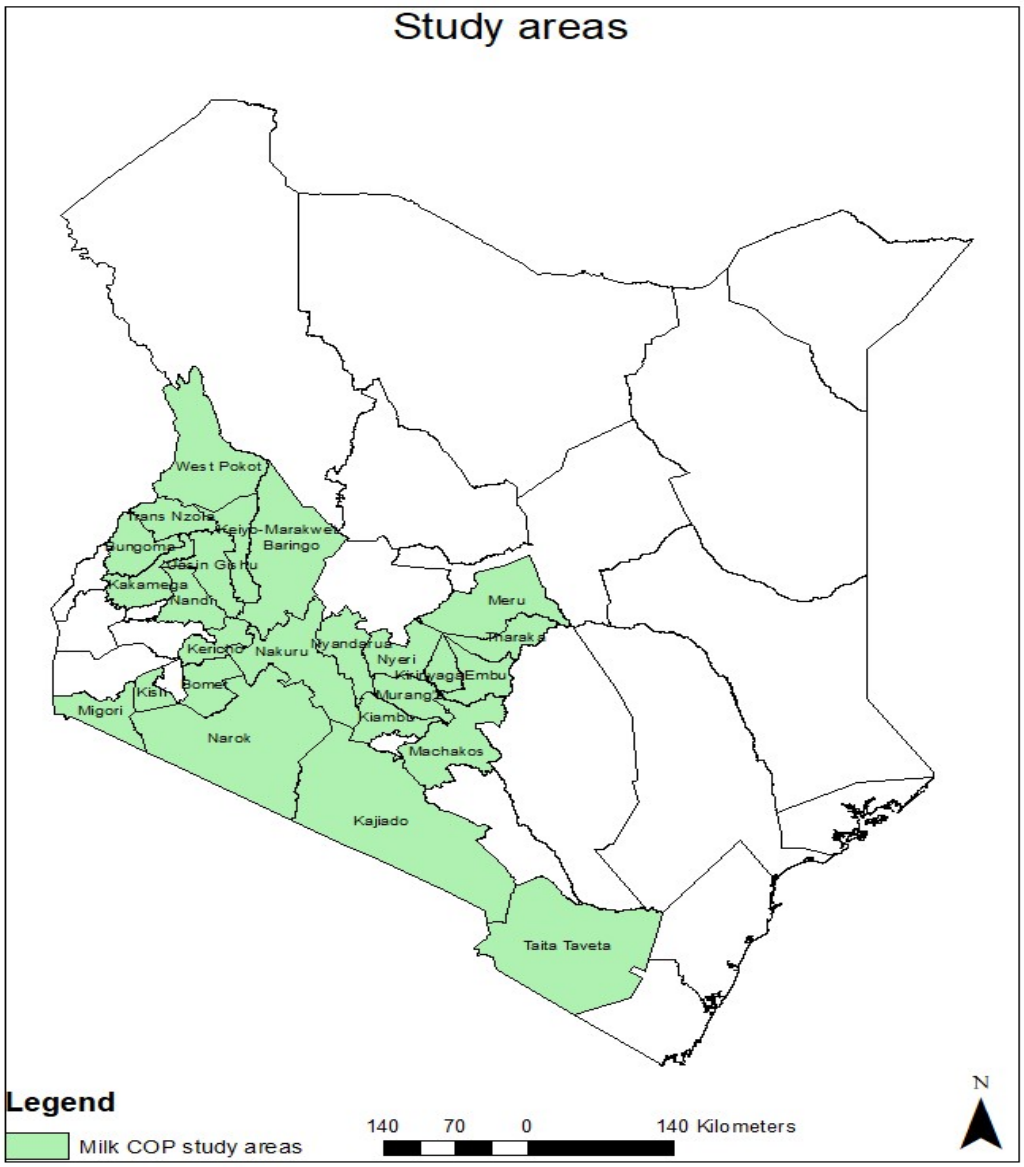

Figure 3: Map of study areas

Table 1: Study Locations

County	Sub-County	Ward	System	Scale
Taita Taveta	Taita	Werughuga	Zero	Small
Meru	Imenti South	Abogeta East	Zero	Small
Nyeri	Mukuruweini	Mukuruweini West	Zero	Small
Muranga	Gatanga	Kariara	Zero	Small
Embu	Manyatta	Ruguru/Ngadori	Zero	Small
Kiambu	Githunguri	Ngewa	Zero	Small
Tharak Nithi	Maara	Chogoria	Zero	Small
Kajiado	Kajiado South	Kuku	Zero	Small
Kericho	Belgut	Cheptororiet/Seretut	Zero	Small
Kirinyaga	Kirinyaga East	Njukiini	Zero	Small
Machakos	Matungulu	Matungulu East	Zero	Small
Bomet	Sotik	Kipsonoi/Kongansis	Semi-zero	Small
Kisii	Bonchari	Bomariba	Semi-zero	Small
Bungoma	Mount Elgon	Kaptama	Semi-zero	Small
Kakamega	Lurambi	Shirere	Semi-zero	Small
Trans Nzoia	Trans Nzoia East	Makutano/Swerwa/Motosiet	Semi-zero	Small
Nyandarua	North Kinagop	Gathaa/Engineer	Semi-zero	Small
Nandi	Chesumei	Lelmokuo/Gecheck/ Kosirai	Semi-zero	Small
Baringo	Eldama Ravine	Ravine/Pakera/Koibatek	Semi-zero	Small
Migori	Rongo	Central Kamagambo	Semi-zero	Small
Uasin Gishu	Ainabkoi	Ainabkoi/Olare	Semi-zero	Medium
Nakuru	Kuresoi South		Open	Small
Elgeyo Marakwet	Keiyo South	Metkei	Open	Medium
Narok	Transmara East	Ilkering	Open	Medium
West Pokot	Lelan	Tabachi/Lelan	Open	Medium

2.2 The typical farm approach

The data required for this study were collected through key informant interviews (KIIs) and focus group discussions (FGDs) with stakeholders in the dairy industry. The FGDs were conducted using the agri-benchmark approach. This approach is a standard operating procedure for defining typical farms and follows a series of steps.

A typical farm is defined by a certain production system and specific structural features such as land ownership and labour organization (family vs. hired). Therefore, a typical farm normally refers to what is common among the majority of the farmers in a particular area in terms of land size, activities, and costs for relevant activities. To ensure the representativeness of the information, typical farms are established in the main production areas, which are of the highest importance for the output of the product in question.

To create typical dairy farms, data collection involved using a panel group of participants comprising farmers in a selected area, and experts from the area who are knowledgeable in dairy production. The experts include livestock production officers, farmer group leaders, dairy cooperative staff, and input sellers. A structured questionnaire was used to collect information from farmers and the experts in a focus group set-up. Using data from a group of farmers rather

than a few individual case studies provides information for a typical farm in the selected area. The role of the experts in the panel is to verify and validate the information collected from the farmers during the exercise. Therefore, data and information provided by farmers were checked to ensure that it reflects the typical situation in the selected area.

The first step in the agri-benchmark approach involved identifying the most important regions and locations for dairy production in the selected counties. Next, the FGD participants specified the dominant production system in the selected locations, i.e., whether zero grazing, semi-zero grazing, or open/free grazing. Third, the FGD participants defined the predominant scale of production in the selected location, i.e., whether small, medium, or large.

2.3 Data collection

As indicated above, data for the typical dairy farms were collected using the agri-benchmark approach through FGDs. In addition, data were collected from model farms in each county through KIIs. Based on discussions between county livestock production officers and the Kenya Dairy Board field staff, model farms were selected. A model farm is a farm whose main purpose is to research or demonstrate different/best agricultural methods and innovations, often used as a benchmark and a learning resource for other farms in the sub-county/ward. Some of the characteristics of a model dairy farm include having a sound investment strategy, proper breeding, keeping accurate records, managing diseases, and addressing fertility-related concerns. The primary goal of a model farm is to demonstrate sustainable and efficient farming techniques that other farmers can imitate. Model farms are not synonymous with commercial farms because not all commercial farms are used as benchmarks in dairy farming. Although it may be argued that 30 model farms may not be sufficient to represent the dairy sector in the country, the model farms were selected to represent different production systems. Therefore, they provide reliable indication of best practices for different production systems. The study has included small, medium and large-scale dairy farms to capture diverse economic realities.

Table *2* shows the number and typology of dairy producers for this study.

Table 2: Typology of dairy producers

	Typical				Model			
	Large	Medium	Small	**Total**	Large	Medium	Small	**Total**
Zero	0	0	11	**11**	2	12	5	**19**
Semi-zero	0	3	7	**10**	0	3	7	**10**
Open	0	3	1	**4**	0	1	0	**1**
Overall	**0**	**6**	**19**	**25**	**2**	**16**	**12**	**30**

Data was collected for 25 typical farms (i.e. one in each of the selected counties), representing the different agro-ecological zones of Kenya, the diversity of milk production systems, and the milk production potential of different counties categorized as high, medium and low. The selection of counties, sub-counties and locations was finalized in consultation with the Kenya

Dairy Board field officers and livestock production officers at the county level. Both qualitative and quantitative data were collected using FGDs (following the typical farm methodology) and KIIs. FGDs consisted of 8-10 farmers randomly selected from different cooperatives to represent the dairy farmers in the selected ward, one ward representative from the department of livestock, one ward representative for livestock input dealers and one processer/cooperative representative.

2.4 Data analysis

2.4.1 Level of analysis

Study results were disaggregated by production system, scale and county, and production costs were presented by the major cost components. Gross margin analysis was conducted to determine the profitability of milk production under the different production systems.

2.4.2 Computation of costs and margins

Costs		**Returns**			
Total Variable Cost (TVC)	Total Cost (TC)	Gross value of milk	Gross margin (**accounting returns**)	Milk profit (**economic returns**)	Whole enterprise profit
Summation of all variable costs (explicit & paid for)	TVC + fixed costs (depreciation) + family labour +own pasture/fodder	Average value of milk sold plus milk consumed by households and fed to calves	Gross value of milk-TVC	Gross value of milk - TC	Gross value of milk – TC + other revenue (manure, livestock sales)

2.4.3 Definition of costs and margins

Total variable costs (TVC): This is a summation of all variable costs. The TVC captured only explicit costs that change with production system level, intensity, and efficiency. Costs for factors not paid for, such as own fodder and family labour, were not included in this category even though they vary with production level.

Total costs (TC): This is TVC plus fixed costs (depreciation of fixed assets) and cost of own factors of production such as family labour and own pasture. Herd depreciation was not considered in this analysis.

Depreciation of fixed assets was calculated using the straight-line method as follows: *Depreciation per annum = (Cost-residual value)/useful life)* where *cost* was the initial acquisition or construction costs related to the asset; *residual value* was the estimated proceeds expected from the disposal of an asset at the end of its useful life; and, *useful life* is the estimated

period that the asset is expected to be used starting from the date it is available for use up to the date of its disposal.

Gross value of milk: This is the value of milk that is sold plus milk consumed by the household. For each typical farm, this was determined using the average of the milk prices offered by different market outlets used by the farmers. Milk fed to calves was considered as part of the revenue in zero and semi-zero grazing systems but not in the open grazing system (this was difficult to determine since calves are often left to suckle directly from the mothers).

Other farm revenue: This includes revenue from sale of livestock and manure, imputed value of manure used on own farm, and bull services.

Gross margin is gross value of milk less TVC. This can also be referred to as accounting returns.

Profit from milk production only (referred hereafter as milk profit) is gross value of milk less TC. This can also be referred to as economic returns.

Profit from whole dairy enterprise (referred hereafter as whole enterprise profit) considers other farm revenues as indicated above.

Since the main output from a dairy enterprise is milk, gross margin and milk profit were the main indicators used to describe returns in this analysis.

3 Results

This section presents the results of the study. Sections 3.1 and 3.2 contain quantitative results on milk production, costs and margins for typical and model dairy farms, respectively. Access to and provision of inputs and services in dairy production are qualitatively discussed in Section 3.4.

3.1 Typical dairy farms

3.1.1 Production characteristics of a typical dairy farm by production system

The characteristics of a typical farm by production system are presented in Table 3. Results indicate that on average, a typical dairy farm had a herd size of seven cattle. In all the production systems (zero, semi-zero and open grazing), about 50 percent of the cattle in the herd were cows. Out of this, nearly 75 percent of the cows were lactating during the reference period (July 2023 to June 2024), indicating that most of the cows in the herd contributed to milk production during the reference period.

The average daily milk yield per cow for the year 2023/24 was 9 litres, translating to 2,797 litres per cow per year (using a lactation period of 300 days per year). The average milk production varied considerably by production system. Farmers practising zero grazing produced 1.5 times more milk than those practising semi-zero grazing and 1.7 times more than those doing open grazing. These differences can be attributed to variations in the quality of breeds, feeding practices among other factors, across the production systems (Brito et.al, 2021; Dias and Fischer, 2021; FAO, 2006). The average producer price of milk offered by the main buyer, which was established to be cooperative societies, was KES 43.5 per litre.

Table 3: Production characteristics of typical dairy farms across production systems in Kenya

Item	Production system			
	Zero grazing (n=11)[2]	Semi-zero grazing (n=10)	Open grazing (n=4)	Overall (N=25)
Average herd size	4	8	8	7
Average number of cows	2	4	4	3
Average number of lactating cows	2	3	3	2
Proportion of lactating cows to herd size (%)	50	38	38	29
Average milk production	6,712	6,333	5,955	6,333
Average yield (litres/cow/year)	3,692	2,533	2,165	2,797
Average daily yield (litres/cow/day)	12.3	8.4	7.2	9.3
Average price per litre offered by main buyer (KES)	48.2	45.4	37.0	43.5
Main buyer	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop

[2] N denotes number of typical farms

3.1.2 Production characteristics of a typical dairy farm by production system and county

a) Zero grazing

The small scale zero grazing was the dominant production system in 11 out of the 25 counties in the study (i.e. Embu, Kajiado, Kericho, Kiambu, Kirinyaga, Machakos, Meru, Murang'a, Nyeri, Taita Taveta and Tharaka Nithi). A typical small scale zero grazing farm had an average herd size of 4 cattle, with 2 cows (Table 4). Farmers mostly kept Friesian crossbreeds. Daily milk yield per cow in this system averaged 12.4 litres, translating to 3,692 litres per cow per year. Kiambu, Kajiado and Kericho had the highest milk yield per cow whereas the lowest yields were in Meru, Kirinyaga and Nyeri. The differences in milk yield across the counties could be due to factors such as cow genetics, livestock feeding and nutrition, health of the cattle, lactation stage, and exposure stress to cows including that due to housing conditions. Cooperative societies were the main buyers of milk from farmers except in Kajiado, Kirinyaga and Machakos, and offered an average price of KES 42.3 per litre of milk.

Table 4: Characteristics of a typical zero grazing dairy farm, by county

Characteristic	County											
	Embu	**Kajiado**	**Kericho**	**Kiambu**	**Kirinyaga**	**Machakos**	**Meru**	**Murang'a**	**Nyeri**	**Taita Taveta**	**Tharaka Nithi**	**Average**
Scale of production	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	
Average herd size	2	5	5	3	4	6	3	5	4	4	3	**4**
Average number of cows	1	2	3	2	2	3	2	3	2	2	2	**2**
Average no. of lactating cows	1	2	2	2	2	1	2	3	2	1	2	**2**
Proportion of lactating cows to herd size (%)	50	40	40	67	50	17	67	60	50	25	67	**50**
Dominant breed	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	
Average annual milk production (litres/year)	3,420	9,660	9,000	10,440	5,640	4,170	4,800	10,350	5,880	3,870	6,600	**6,712**
Average daily milk yield (litres/cow/day)	11.4	16.1	15.0	17.4	9.4	13.9	8.0	11.5	9.8	12.9	11.0	**12.4**
Average annual milk yield (litres/cow/year)	3,420	4,830	4,500	5,220	2,820	4,170	2,400	3,450	2,940	3,870	3,300	**3,692**
Proportion of milk sold (%)	88	89	83	89	91	85	85	91	72	74	90	**85**
Average price per litre by main buyer in 2024 (KES/litre)	46.0	66.7	46.3	48.0	50.0	52.3	54.7	44.3	42.3	45.0	55.0	**50.1**
Main buyer type	Dairy Coop.	Traders	Dairy Coop	Dairy Coop	Traders	Traders	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	

b) Semi-zero grazing

The semi-zero grazing production system was typical in 10 out of the 25 counties. In seven of the counties (Baringo, Bungoma, Kakamega, Kisii, Migori, Nyandarua and Trans Nzoia), small scale, semi-zero grazing was the dominant system. In contrast, in Bomet, Nandi and Uasin Gishu, the semi-zero grazing system was medium-scale. The cows kept in semi-zero grazing systems were Friesian and Ayrshire crossbreeds.

The small-scale semi-zero grazing farms had an average of 6 cows with two lactating and producing an average of 8.5 litres per cow per day, translating to 2,552 litres per cow per year (Table 5). Daily milk yield per cow in this production system and scale was highest in Baringo (11.6 litres) and lowest in Migori (5.7 litres). The average producer price offered by the leading milk buyer was KES 46.5. The main buyers of milk differed across the counties and included cooperative societies (Baringo, Bungoma, Nyandarua and Trans Nzoia), individual or institutional consumers (Kakamega) and milk vendors (Kisii and Migori). The average producer price of milk was highest in Kakamega, where the main buyers were individual or institutional consumers, and lowest in Bungoma, Baringo, Trans Nzoia and Nyandarua, where the main buyers were cooperative societies. This suggests that direct buyers (consumers or institutions) tend to pay more per unit, possibly because they purchase smaller quantities at retail or near-retail prices. The contrast in milk prices across regions underscores the importance of local market conditions. Each area's unique demand and buyer structure can significantly influence producers' earnings. Diversifying buyer bases, even within cooperatives, could offer a way to stabilize and potentially raise producer prices across different regions.

For medium-scale semi-zero grazing farms (in Bomet, Nandi and Uasin Gishu), the average herd size was 12 cows with four lactating. Similar to their small-scale counterparts, medium-scale semi-zero grazing dairy farms produced an average of 8.5 litres per cow per day, translating to 2,551 litres per cow per year (Table 6). The daily milk yield per cow in the medium-scale semi-zero grazing system was highest in Bomet (10.9 litres) and lowest in Uasin Gishu (7.1 litres). The main buyer of milk was the cooperative society, which offered an average price of KES 46.5, with the price being lowest in Uasin Gishu and highest in Bomet.

Table 5: Characteristics of a typical semi-zero grazing dairy farm (small-scale), by county

Characteristic	**County**							
	Baringo	**Bungoma**	**Kakamega**	**Kisii**	**Migori**	**Nyandarua**	**Trans Nzoia**	**Average (SS)**
Scale of production	SS	SS	SS	SS	SS	SS	SS	
Average herd size	10	4	5	6	7	4	5	**6**
Average number of cows	5	2	3	2	3	2	3	**3**
Average no. of lactating cows	3	1	1	2	3	2	2	**2**
Proportion of lactating cows to herd size (%)	33	25	20	33	43	50	40	**33**
Dominant breed	Friesian	Ayrshire	Ayrshire	Friesian	Friesian	Friesian	Ayrshire	
Average annual milk production (litres/year)	10,410	2,280	2,550	5,310	5,160	5520	4,860	**5,156**
Average daily milk yield (litres/cow/day)	11.6	7.6	8.5	8.9	5.7	9.2	8.1	**8.5**
Average annual milk yield (litres/cow/year)	3,470	2,280	2,550	2,655	1,720	2,760	2,430	**2,552**
Proportion of milk sold (%)	78	75	86	80	91	73	81	**81**
Average price per litre by main buyer in 2024 (KES/litre)	41.1	34.0	75.0	50.0	50.0	42.7	42.5	**46.5**
Buyer type	Dairy Coop	Dairy Coop	Consumers	Private milk vendors	Private milk vendors	Dairy Coop	Dairy Coop	

Table 6: Characteristics of a typical semi-zero grazing dairy farm (medium scale), by county

Characteristic	County			
	Bomet	Nandi	Uasin Gishu	Average (MS)
Scale of production	MS	MS	MS	
Average herd size	10	10	15	**12**
Average number of cows	4	5	7	**5**
Average no. of lactating cows	3	3	5	**4**
Proportion of lactating cows to herd size (%)	33	33	30	**30**
Dominant breed	Friesian	Ayrshire	Friesian	
Average annual milk production (litres/day)	9,810	6,720	10,710	**9,080**
Average daily milk yield (litres/cow/day)	10.9	7.5	7.1	**8.5**
Average annual milk yield (litres/cow/year)	3,270	2,240	2,142	**2,551**
Proportion of milk sold (%)	72	84	71	**75**
Average price per litre by main buyer in 2024 (KES/litre)	41.7	40.4	37.0	**39.7**
Buyer type	Dairy Coop	Dairy Coop	Dairy Coop	

c) Open grazing

The open grazing production system was prevalent in 4 out of 25 counties. Small-scale open grazing system was typical in Nakuru County while medium scale one was typical in Elgeyo Marakwet, Narok and West Pokot. The breeds kept in these production systems were mainly Friesian crossbreeds, except in Narok where Ayrshire crossbreed was dominant.

Small scale open grazers in Nakuru had an average of four cows with 2 lactating and producing 6.9 litres of milk per cow per day, translating to 2,070 litres per cow per year (Table 7). The milk from this system was sold mainly to cooperative societies, which offered farmers an average price of KES 42 per litre of milk.

Table 7: Characteristics of a typical open grazing dairy farm (small-scale), by county

Characteristic	County
	Nakuru
Scale of production	SS
Average herd size	4
Average number of cows	2
Average no. of lactating cows	2
Dominant breed	Friesian
Average annual milk production (litres/year)	4,140
Average daily milk yield (litres/cow/day)	6.9
Average annual milk yield (litres/cow/year)	2,070
Proportion of milk sold (%)	79
Average price per litre by main buyer in 2024 (KES/litre)	41.9
Main buyer	Dairy Coop

Medium scale open grazers had an average of 10 cows with 3 lactating and producing an average of 7.3 litres of milk per day; annual milk production per cow per year averaged 2,187 litres (Table 8). Milk yield was highest in Elgeyo Marakwet. The main buyer of milk was co-operative societies, which offered farmers an average price of KES 35.8 per litre of milk. In Narok, however, milk vendors were the main buyers and offered the lowest producer price of KES 34 per litre.

Table 8: Characteristics of a typical open grazing dairy farm (medium scale), by county

Characteristic	County			
	Elgeyo Marakwet	Narok	West Pokot	Average
Scale of production	MS	MS	MS	
Average herd size	11	7	11	10
Average number of cows	6	3	5	5
Average no. of lactating cows	4	2	3	3.0
Proportion of lactating cows to herd size (%)	36	29	27	30
Dominant breed	Friesian	Ayrshire	Friesian	
Average annual milk production (litres/year)	9,600	3,600	6,480	6,560
Average daily milk yield (litres/cow/day)	8.0	6.0	7.2	7.3
Average annual milk yield (litres/cow/year)	2,400	1,800	2,160	2,186.7
Proportion of milk sold (%)	84	75	70	77
Average price per litre by main buyer in 2024 (KES/litre)	38.0	33.5	36.0	35.8
Main buyer	Dairy Coop	Private milk Vendors	Dairy Coop	

3.1.3 Costs and margins in milk production on typical farms

3.1.3.1 Costs and margins in milk production by production system

The costs of and returns to milk production as well as the ratios that measure the efficiency in production in typical dairy farms are presented in Table 9. The value of milk produced by a typical dairy producing household consists of value of milk sold, consumed by the household and fed to calves. Average milk prices received from different buyers were used to calculate the gross value of milk. As presented in the previous section, different milk buyers offered different prices to dairy farmers. The gross value of milk per litre averaged KES 46.1. Zero grazing farms had the highest gross value per litre of milk (KES 49.3), while open grazers had the lowest (KES 38.4) (Table 9).

On average, total variable cost (TVC) and total cost (TC) per litre of milk were highest among the farms in zero grazing system and lowest among the open grazing farms (Table 9). The total variable cost per litre of litres milk for a typical zero grazing farm was KES 23.8, which was 1.6 times higher than for a typical semi-zero grazing farm and 2.8 times higher than for an open grazer. The substantial utilization of feed concentrates and purchased feed/pasture is the primary factor contributing to the much higher total variable cost for zero grazers. The average gross margin per litre of milk was lowest for zero grazers (KES 25.5) and highest in the semi-

zero grazing system (KES 30.6). The dairy enterprise's profitability across the three production systems is evident from the positive gross margins, as the producers were able to cover total variable costs.

Table 9: Average costs and margins per litre of milk production, by production system

	Zero grazing (n=11)	Semi-zero grazing (n=10)	Open grazing (n=4)	Overall (N=25)
Gross value of milk[3] (sold/consumed/fed to calf)	**49.3**	**45.7**	**38.4**	**46.1**
Value of milk sold	41.9 (85)[4]	34.3 (75)	29.8 (77.7)	36.4 (79)
Value of milk consumed	5.4 (10.9)	10.0 (21.9)	17.5 (22.3)	8.3 (18)
Value of milk given to calves	2.0 (4.1)	1.4 (3.1)	0 (0)	1.4 (3)
Purchased fodder/pasture	5.1	0.3	0.2	2.4
Hired labour	2.2	3.5	0.0	2.3
Health and breeding costs	1.8	3.0	3.2	2.5
Mineral salts	1.2	1.4	2.1	1.4
Other costs (e.g. electricity, fuel)	0.7	0.2	0.0	0.4
Repairs on fixed assets	0.6	0.7	0.7	0.7
Water (purchased)	0.4	0.1	0.1	0.2
Milking jelly	0.2	0.3	0.2	0.2
Total variable costs (TVC)	**23.8**	**15.1**	**8.5**	**17.9**
Gross margin (revenue - TVC)	**25.5**	**30.6**	**29.9**	**28.2**
Family labour	10.7	11.1	9.8	10.7
Own fodder/pasture	5.0	11.2	6.2	7.7
Total costs (TC = TVC + own labour + own fodder)	**39.5**	**37.3**	**24.5**	**36.2**
Milk profits (revenue - TC)	**9.8**	**8.4**	**13.9**	**9.9**
Other revenue (sale of livestock, manure, bull services)	5.0	3.2	6.2	4.5
Whole enterprise profit (milk profits+ other revenue)	**14.8**	**11.6**	**20.1**	**14.4**
Gross margin/TVC ratio	1.2	2.9	4.3	2.4
Gross margin rate (%)	50.5	67.4	78.0	61.7

The total cost (which includes total variable cost, depreciation, cost of own labour and cost of own fodder/pasture) per litre of milk averaged KES 36.2, with zero grazing farmers having 1.1 times higher total cost than semi-zero grazers and 1.6 times higher than open grazers. Conversely, open grazing system farmers had the highest milk profit per litre of milk (KES

[3] Also referred to as gross revenue from milk

[4] The figures in brackets are the proportion of milk that each of the uses contributes to gross value of milk produced. For instance, under the zero grazing system, 85% of the milk is sold, 10.9% is consumed at home, while 4.1% is fed to calves.

13.9), followed by zero grazers (KES 9.8) and farmers practising semi-zero grazing (KES 8.4). These results, however, indicate that despite the differences in their costs, dairy farmers in all the three production systems were able to cover their TVC, cost of fixed assets, cost of own labour and fodder/pasture and make profit. Overall, whole enterprise profit averaged KES 14.4 per litre of milk, with open grazers realizing the highest profit (KES 20.1) while zero grazers the lowest (KES 14.8).

The ratio of gross margin to TVC represents the contribution to the gross margin for every shilling spent on variable expenses. It measures how much a dairy farm generates for every unit of variable cost, and it is an indicator of how efficiently a dairy farm can cover variable costs. On average, KES 2.4 was earned for every shilling spent on variable costs to produce one litre of milk. Open grazers made the highest returns (KES 4.3) whereas the zero grazers made the lowest returns (KES 1.2). This indicates that on average, a dairy farmer in the open grazing system generated more returns relative to variable costs compared to zero grazers and semi-zero grazers.

The gross margin rate (calculated as the ratio of gross margin to total revenue per litre of milk) represents the percentage of gross revenue that is available to cover total fixed cost, cost of own labour, cost of own fodder/pasture and farmers' profit. The average gross margin rate was 61.7%, with open grazers having the highest rate (78%) and zero grazers the lowest (50.5%), indicating that dairy production in the open grazing system was more profitable than in zero grazing and semi-zero grazing systems.

3.1.3.2 Costs and margins in milk production by production system and county

a) Zero grazing

The average gross revenue per litre of milk in small scale zero grazing systems was KES 49.3, with Kajiado county having the highest gross revenue (KES 64) and Nyeri county the lowest (KES 41.5) (Table 10). The average total variable cost was KES 23.8, with variations across the study counties. Small-scale zero-grazing farms in Kirinyaga had the lowest total variable cost (KES 17), while the costs were highest in Kiambu (KES 32.9) and Murang'a (KES 32.4).

Feed concentrates were the largest driver of total variable cost in Kiambu, contributing about 67%, whereas in Murang'a, purchased fodder/pasture accounted for the highest proportion (48%) of the total variable cost. Small-scale zero-grazing farmers in Kericho and Meru did not incur expenses on purchased fodder/pasture, whereas those in Machakos did not purchase feed concentrates.

Among the small-scale zero-grazing farms, those in Kajiado had the highest gross margin per litre of milk on average (KES 43.7), followed by Meru (KES 36.5) and Tharaka Nithi (KES 34.1). The high gross margins in the three counties are driven by higher milk prices (gross revenue per litre of milk) relative to prices in other counties. Small-scale zero grazers in Murang'a and Kiambu had the lowest gross margins (KES 11.5 and 15.1, respectively), mainly due to higher total variable costs than other counties. Overall, the positive gross margins

indicate that small-scale dairy farmers under zero-grazing systems in the study areas could cover total variable costs during the reference period (the year 2023/24).

The average total cost (i.e. the sum of variable costs, fixed costs, cost of own labour and own fodder/pasture) was KES 39.5 per litre of milk for a small-scale zero-grazing farm. Farmers in Taita Taveta incurred the highest total cost (KES 50), followed by Embu (KES 48.4) and Nyeri (KES 44.8). The highest contributor to the total cost in Taita Taveta and Embu were family labour, while own fodder and own labour had equal contribution to the total cost in Nyeri. Typical small-scale zero-grazing dairy farmers in Kericho and Murang'a reported not using family labour in dairy farming.

The highest profit per litre of milk was reported in Kajiado (KES 26.3), followed by Meru (KES 24) and Tharaka Nithi (KES 16.2). It is noteworthy that milk prices for small-scale zero grazers in these counties were the highest. Farmers in Embu, Nyeri and Taita Taveta made economic losses of KES 2.4, KES 3.3, and KES 6.3, respectively. These losses were mainly due to the high costs of family labour and feed concentrates. The high cost of labour can deter farmers from engaging in dairy farming, but investments in mechanization, such as the use of a chaff cutter, can offset labour costs and boost productivity. However, the small scale of the dairy farms and small herd sizes may limit the benefits of labour-substitution technology. Even with alternative revenues such as the sale of livestock and manure, small-scale zero grazers in Taita Taveta still made a loss of KES 5 per litre of milk produced. Small-scale zero grazing dairy farms in Nyeri made the highest whole enterprise profit of KES 29 per litre of milk.

For every shilling invested in variable cost to produce one litre of milk, Kajiado had the highest return of KES 2.1 while Kiambu had the lowest (KES 0.5). Gross margin rate was highest in Kajiado (68.2%) and lowest in Murang'a (26.2%).

Table 10: Summary of costs and margins (KES) per litre of milk production for zero grazing typical farms (small-scale)

Production system	**County**											
County	**Embu**	**Kajiado**	**Kericho**	**Kiambu**	**Kirinyaga**	**Machakos**	**Meru**	**Murang'a**	**Nyeri**	**Taita Taveta**	**Tharaka Nithi**	**Average (SS)**
Gross revenue from milk (sold +consumed)	46.0	64.0	45.6	48.0	50.0	49.7	54.7	43.9	41.5	43.7	55.0	49.3
Total variable costs (TVC)	26.8	20.3	24.5	32.9	17.0	22.8	18.2	32.4	19.2	26.3	20.9	23.8
Gross margin (revenue - TVC)	19.2	43.7	21.1	15.1	33.0	26.9	36.5	11.5	22.2	17.5	34.1	25.5
Total costs (TC = TVC + depreciation + own labour + own fodder)	48.4	37.7	34.3	42.9	36.2	36.2	30.7	34.3	44.8	50.0	38.8	39.5
Milk profits (revenue - TC)	-2.4	26.3	11.3	5.1	13.8	13.5	24.0	9.6	-3.3	-6.3	16.2	9.8
Whole enterprise profit	1.1	26.6	12.0	6.7	18.1	17.1	24.0	9.9	29.0	-5.0	23.8	14.8
Gross margin/TVC ratio	0.7	2.1	0.9	0.5	1.9	1.2	2.0	0.4	1.2	0.7	1.6	1.2
Gross margin rate (%)	41.7	68.2	46.2	31.4	66.0	54.1	66.7	26.2	53.6	39.9	61.9	50.5

Note: Full results are shown in Table A1 in the Appendix

b) Semi-zero grazing

A summary of costs and margins per litre of milk produced for small scale semi-zero grazing farms is presented in Table 11. Dairy farms in Kakamega county had the highest milk revenue per litre of milk (or price of milk) of KES 75 while Bungoma had the lowest price (KES 34.8). Total variable cost per litre of milk was highest in Kisii (KES 31.5) and lowest in Bungoma (KES 4.7). Feed concentrates and hired labour were the main factors driving variable costs in Kisii. Bungoma had the least variable cost. While farmers incurred costs on health and breeding, milking jelly and repairs on fixed assets, they did not purchase feed concentrates, fodder or pasture. Only farmers from Kakamega and Kisii incurred costs on purchased fodder/pasture.

Small scale semi-zero grazing dairy farms in Kakamega county had the highest gross margin (KES 57.5), due to a combination of high milk price and relatively low total variable cost. It is worth noting that consumers were the main buyers of milk from farmers in Kakamega, paying higher prices compared to those paid by other main buyers in other counties. Small scale semi-zero grazing farmers in Kisii county had the lowest gross margin despite having the second highest gross revenue per litre of milk, because of the high total variable cost. Conversely, farmers in Kakamega incurred the highest total cost (KES 47.9), where the cost of family labour accounted for the largest proportion of total cost. The total cost in Bungoma was also driven mainly by high costs of family labour and own fodder/pasture. Reflecting the high gross revenue per litre of milk, Kakamega county had the highest milk profits per litre (KES 27.1) despite having the highest total cost.

The highest gross margin/TVC ratio and gross margin rate were reported in Bungoma. This indicates that even though small scale semi-zero grazing dairy farmers in Bungoma were not making a profit overall, for every shilling they invested in variable cost in producing a litre of milk, they received a return of KES 6.5, but this return was not adequate to cover fixed costs and costs of own labour and own fodder/pasture.

Table 11: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing farms (small-scale)

Production system	**County**							
	Baringo	**Bungoma**	**Kakamega**	**Kisii**	**Migori**	**Nyandarua**	**Trans Nzoia**	**Average (SS)**
Gross revenue from milk (sold +consumed)	47.1	34.8	75.0	50.0	50.0	44.4	41.1	48.9
Total variable costs (TVC)	15.5	4.7	17.5	31.5	23.7	10.4	7.9	15.9
Gross margin (revenue - TVC)	31.6	30.1	57.5	18.5	26.3	34.0	33.2	33.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	34.3	36.8	47.9	46.9	45.5	42.6	33.7	41.1
Milk profits (revenue - TC)	12.8	-2.0	27.1	3.1	4.5	1.8	7.4	7.8
Whole enterprise profit	18.2	-2.0	34.8	5.0	7.4	1.8	10.1	10.8
Gross margin/TVC ratio	2.0	6.5	3.3	0.6	1.1	3.3	4.2	3.0
Gross margin rate (%)	67.1	86.6	76.7	36.9	52.6	76.6	80.8	68.2

Note: Full results are shown in Table A2 in the Appendix

For the medium scale semi-zero dairy farms, gross revenue per litre of milk averaged KES 38 and was similar in all the counties (Table 12). Bomet county had the highest total variable cost per litre of milk (KES 21.3) and Nandi the lowest (KES 6.3). Feed concentrates were the main drivers of variable costs in Bomet, while only farmers in Nandi incurred purchased fodder/pasture.

Medium scale semi-zero grazing dairy farms in Nandi County had the highest gross margin per litre of milk of KES 31.7, mainly due to relatively low total variable costs. Farmers in Bomet County had the lowest gross margin because of relatively high total variable costs. Despite having lowest total variable costs compared to their counterparts in Bomet and Uasin Gishu, farmers in Nandi County had the highest total cost (KES 35.5) where family labour was the main driver of the costs. Farmers in Uasin Gishu recorded the highest milk profit (KES 17.9) and the highest whole enterprise profit (KES 19.1).

The highest gross margin/TVC ratio and gross margin rate were reported in Nandi; for every shilling a farmer invested in variable cost in producing a litre of milk, the farmers received a return of KES 5.

Table 12: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing farms (medium scale)

Production system	**County**			
	Bomet	**Nandi**	**Uasin Gishu**	**Average (MS)**
Gross revenue from milk (sold +consumed)	38.7	38.0	37.9	38.2
Total variable costs (TVC)	21.3	6.3	12.1	13.2
Gross margin (revenue - TVC)	17.4	31.7	25.7	24.9
Total costs (TC = TVC + depreciation + own labour + own fodder)	29.9	35.5	20.0	28.5
Milk profits (revenue - TC)	8.8	2.5	17.9	9.7
Whole enterprise profit	8.8	12.9	19.1	13.6
Gross margin/TVC ratio	0.8	5.0	2.1	2.7
Gross margin rate (%)	44.9	83.5	68.0	65.4

Note: Full results are shown in Table A3 in the Appendix

c) Open grazing

Table 13 presents the summary of costs and margins (KES) per litre of milk produced for small scale open grazing farms which were only in Nakuru county. They incurred a total variable cost of KES 15, driven by high cost of feed concentrates and total cost of KES 32.1, with family labour being the main driver of the costs.

Results in Table 14 show that medium scale open grazers in Elgeyo Marakwet had the highest gross revenue of KES 45.2 per litre of milk while those in Narok had the lowest (KES 32.9). None of the medium scale open grazing dairy farms purchased feed concentrates or hired labour. Similar to the level of gross revenue per litre of milk, medium scale open grazers in Elgeyo Marakwet had the highest gross margin (KES 38.7), while those in Narok had the lowest. Open grazers in Elgeyo Marakwet had the highest milk profits (KES 22.9), while those

in Narok had the highest whole enterprise profit (KES 27.4). The highest gross margin/TVC ratio was reported in Elgeyo Marakwet. Open grazers in Elgeyo Marakwet and West Pokot had the highest gross margin rate of about 86%.

Table 13: Summary of costs and margins (KES) per litre of milk production for open grazing farms (small scale)

County	**Nakuru**
Gross revenue from milk (sold +consumed)	41.9
Total variable costs (TVC)	15.0
Gross margin (revenue - TVC)	26.9
Total costs (TC = TVC + depreciation + own labour + own fodder)	32.1
Milk profits (revenue - TC)	9.8
Whole enterprise profit	13.4
Gross margin/TVC ratio	1.8
Gross margin rate (%)	64.2

Note: Full results are shown in Table A4 in the Appendix

Table 14: Summary of costs and margins (KES) per litre of milk production for open grazing farms (medium scale)

	County			
	Elgeyo Marakwet	**Narok**	**West Pokot**	**Average (MS)**
Gross revenue from milk (sold +consumed)	45.2	32.9	33.6	37.2
Total variable costs (TVC)	6.5	7.7	4.8	6.3
Gross margin (revenue - TVC)	38.7	25.2	28.8	30.9
Total costs (TC = TVC + depreciation + own labour + own fodder)	22.3	22.1	21.5	21.9
Milk profits (revenue - TC)	22.9	10.8	12.1	15.3
Whole enterprise profit	22.9	27.4	16.8	22.4
Gross margin/TVC ratio	5.9	3.3	6.0	5.1
Gross margin rate (%)	85.5	76.7	85.8	82.7

Note: Full results are shown in Table A5 in the Appendix

3.1.4 Relative contribution of inputs to the total cost of milk production

The broad categories of cost items and their share in the total cost of milk production are presented in Figure 4. Feeds accounted for the largest share (between 43 and 58%) in total cost of production across all the three production systems, while labour followed closely at between 33 and 40 percent. For open grazers, expenses for animal health and breeding were a substantial component in total production cost.

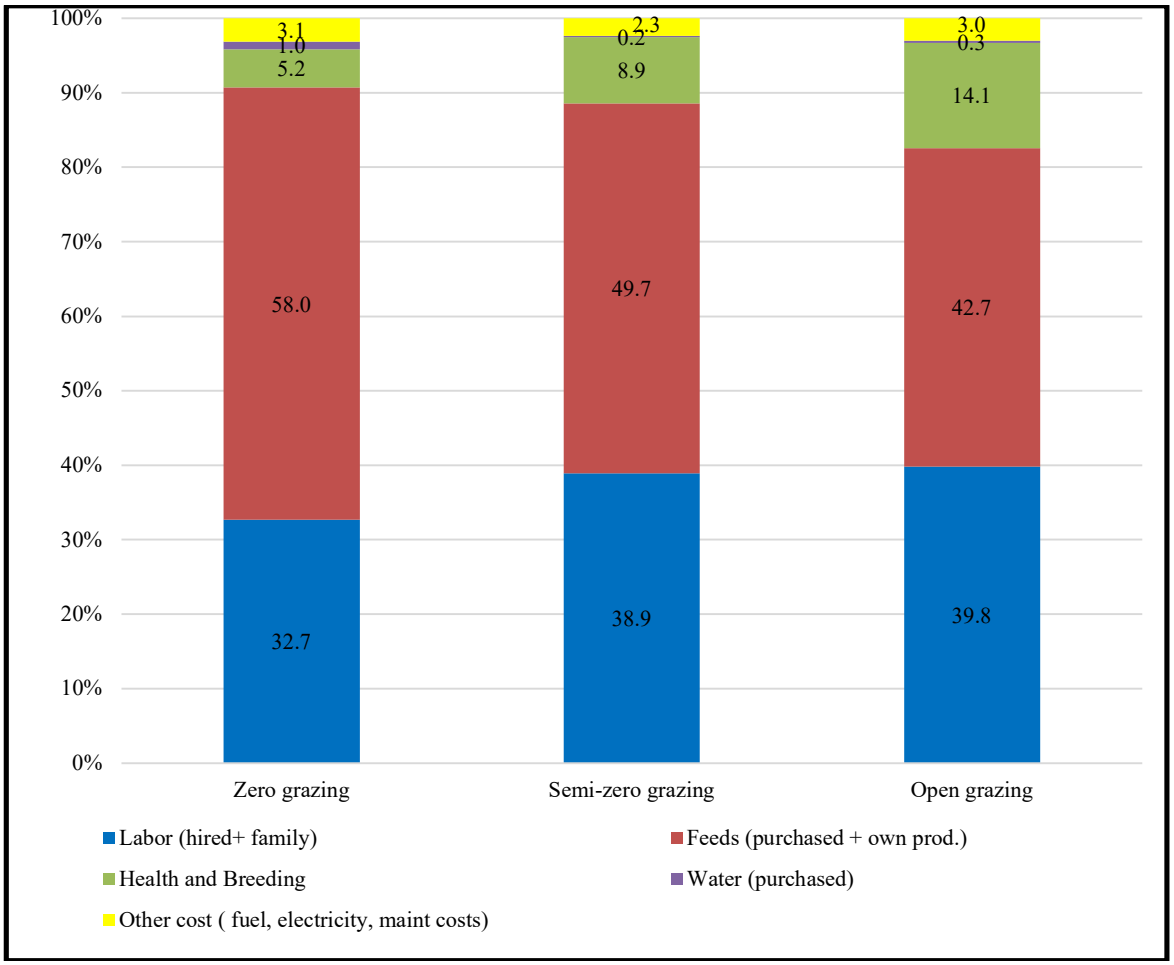

Figure 4: Contribution of cost components in total cost of production- Typical farm (%)

The breakdown of cost components and their shares in total variable cost (TVC) for the different production systems are shown in Figure 5. As expected, feed concentrates accounted for the largest share (48.9%) in TVC while purchased fodder/pasture accounted for 21.3% of the TVC for zero grazers. Labour costs are also notable in the zero-grazing system, where routine activities including livestock feeding, cleaning, and general care demand intensive use of labour. While not as large as feed costs, the share of health and breeding costs (7.8%) is an important cost component of TVC in zero grazing system. Overall, the cost of feed is a critical area to consider in cost reduction strategies in zero grazing dairy production systems in Kenya.

For semi-zero grazing, feed concentrates remain the largest contributor to TVC (at 37.7%), but its share is smaller than in the zero grazing system as would be expected due to the partial use of open grazing, which lowers dependence on purchased feed. The share of hired labour (22.9%) becomes much more significant in semi-zero grazing, reflecting the need to manage cattle in both confinement and when grazing. Health and breeding costs are also a large component (20.2%) in TVC, since cattle grazing in open fields are more exposed to pests and diseases, driving up the costs of health management. Feed concentrates still represent a significant cost in semi-zero grazing system and should be a priority in cost-saving strategies for dairy production.

Health and breeding costs have the largest share (37.9%) in TVC in the open grazing system. As cattle roam more freely, they are exposed to higher pests and disease risks, making expenditures on health management a critical factor in TVC. The cost of mineral salts (at 24.3%) is a much larger cost component in open grazing than in the other two systems, possibly due to nutrient deficiencies in the natural pasture, which must be addressed through providing mineral supplements to livestock. The cost share of feed concentrates (22.7%) is still significant but much lower than in zero and semi-zero grazing systems, since cattle feed primarily on pasture. The cost share of repair of fixed assets (8.6%) is higher than in other systems, mainly because of frequent need to repair paddock fences.

In summary, each of the three production systems has a distinct cost structure, influenced by the main contributors to the total variable costs, which determine the cost reduction strategies and opportunities. However, the cost of feed, especially feed concentrates, labour and animal health and breeding remain the major components in total variable cost in dairy production.

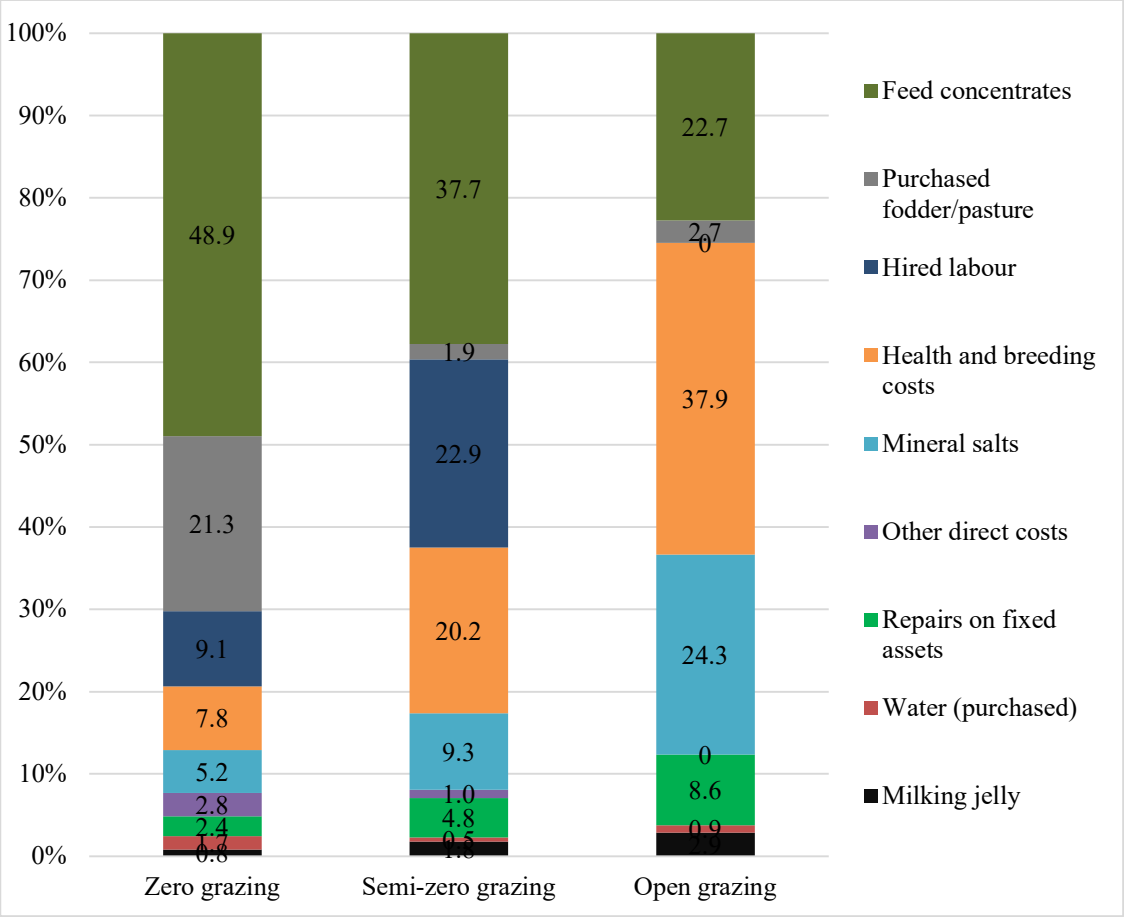

Figure 5: Contribution of cost components in total variable cost of production- broken down by source- Typical farm (%)

The shares of various components in total cost of production across the three production systems are presented in Figure 6. The pattern in cost shares is generally similar to that in TVC. For zero grazers, feed concentrates, family labour, own fodder/pasture and purchased fodder/pasture in that order had the largest share in total cost. For both semi-zero grazers and

open grazers, own fodder/pasture and family labour had the largest share. Further, feed concentrates, and health and breeding costs had substantial shares in total cost for semi-zero and open grazers, respectively. The shares of different components in TVC and TC by county are in the Appendix in Table A14 and Table A15.

Overall, these findings suggest the need to reduce the cost of feed, labour and health, as well as improve labour efficiency to enhance the profitability of dairy production in Kenya.

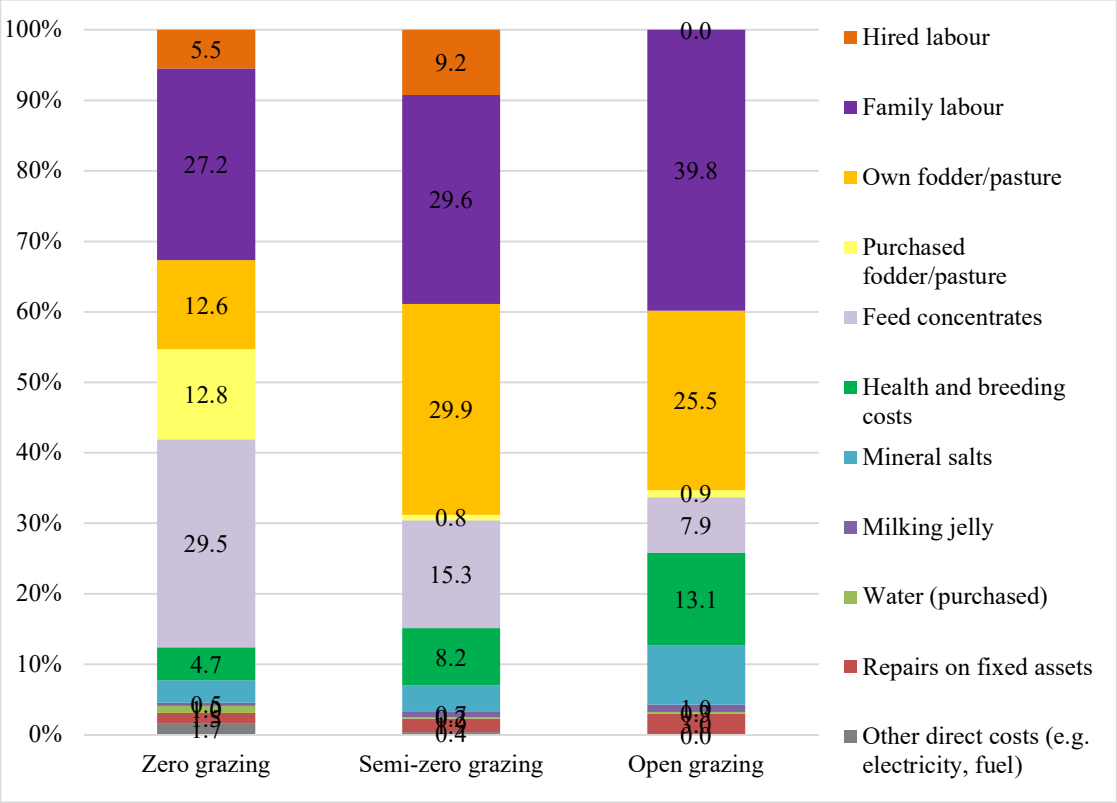

Figure 6: Contribution of cost components in total cost of production- broken down by source- Typical farm (%)

3.1.5 Costs and margins of milk production per lactating cow

In this section, we present the costs and returns per lactating cow. The returns can be used as a proxy for efficiency. However, we note that the proxy is not a perfect efficiency indicator because different counties received different average milk prices. As this study has shown, milk prices are essential in determining farmer returns. Milk production margins per lactating cow can be used as a proxy for efficiency. Figure 7 shows that the zero-grazing system had the highest gross revenue (KES 184,154) per lactating cow, while the open grazing had the lowest (KES 81,724). The TVC and TC were highest in the zero-grazing production system and lowest in the open-grazing production system. Despite the low TVC, open grazing had the lowest gross margins (KES 64,013). Moreover, zero grazing was doing well in gross margins (KES 90,739), milk profits (KES 36,482) and whole enterprise profits (KES 52,656) per lactating cow.

Considering TC and other revenues, the semi-zero grazing had the lowest milk profits (KES 22,089) and whole enterprise profits (KES 30,139).

The costs and margins per lactating cow among typical farms across production systems and county are in the Appendix (Figure A1, Figure A2, and Figure A4).

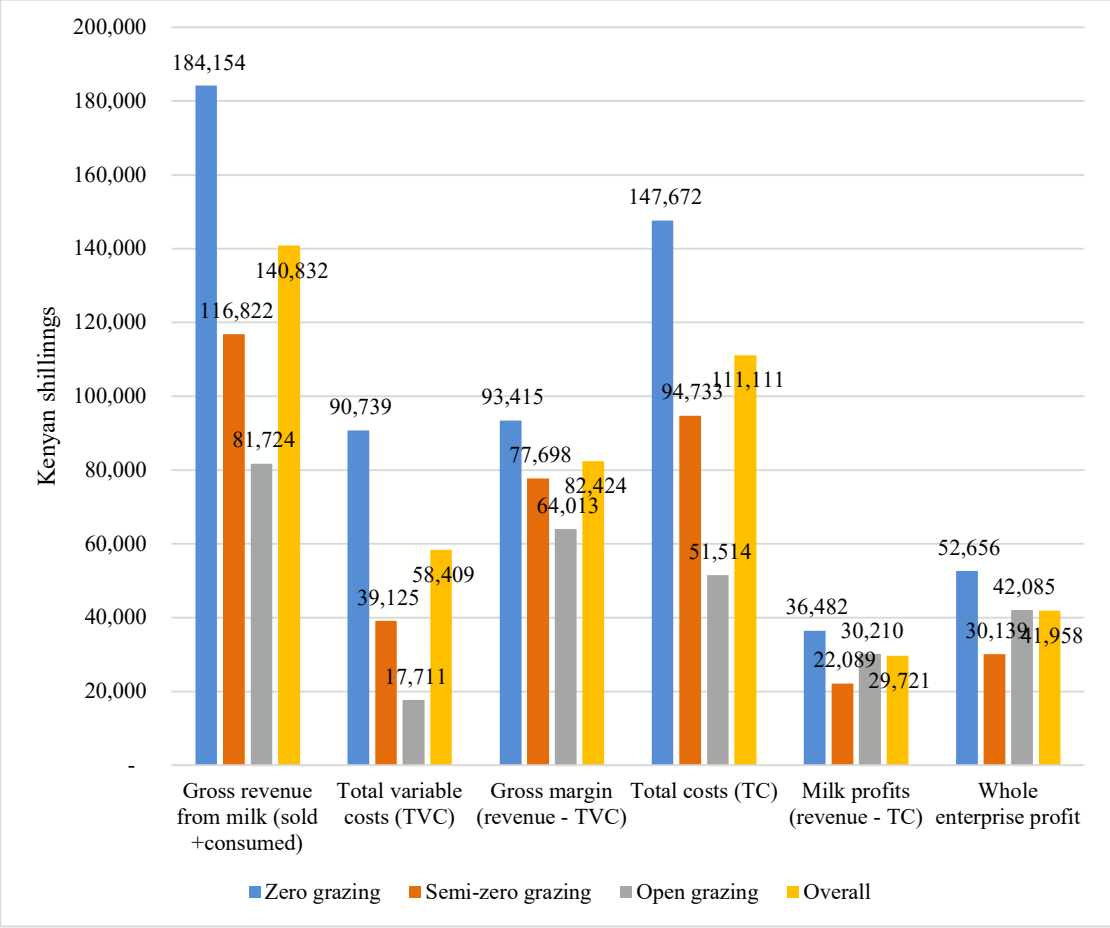

Figure 7: Costs and margins (KES) per lactating cow, by production systems

3.1.6 Changes in costs and margins as a result of changes in cost structure

In this section, we simulate the effect of various factors on production costs, gross margin, and profitability. This approach allows us to identify areas where policy interventions and other investments could help lower costs or enhance returns. We model the effect of a 10% change in individual costs on TVC, while holding the costs of other factors constant. Our analysis focuses on variable costs, as these are more easily influenced by policy adjustments.

3.1.7 Important factors in determining total variable costs (TVC)

From the analysis in the previous section, feed concentrates, hired labour, purchased fodder/pasture, and health and breeding costs emerged as the key contributors to TVC. Therefore, the simulation will focus on these factors. For zero-grazers, the greatest reduction

in TVC would result from lowering the cost of feed concentrates (Figure 8). A 10% reduction in the cost of feed concentrates (holding the costs of other factors constant) would lead to a 4.9% decline in TVC for zero grazers. Similarly, a 10% reduction in the cost of purchased fodder or hired labour would each result in a 2.1% decrease in TVC. Across counties practising zero grazing, a 10% reduction in feed concentrate costs would yield the largest decrease of 7.9% in TVC for farmers in Meru County, followed by Kiambu (5.5%), and around 5% in Nakuru and Nyeri (Table A16 in the Appendix). Similarly, TVC would decrease by 5.3% and 3.8% in Murang'a and Nakuru, respectively, with a 10% reduction in purchased fodder costs. For hired labour, the largest reduction of about 3.7% and 2.6% would be realized in Machakos and Kericho, respectively.

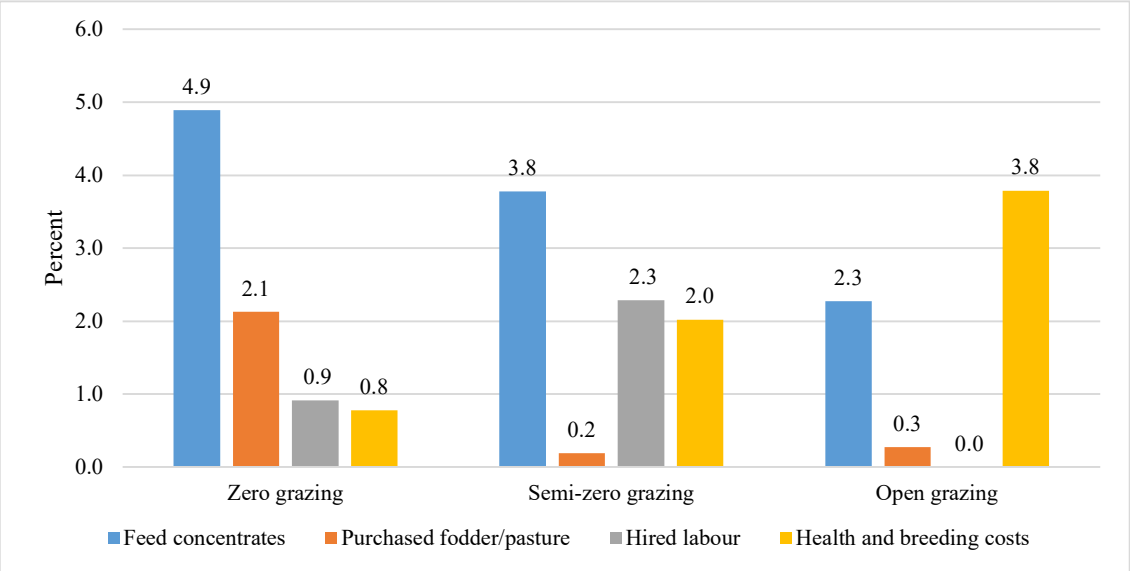

Figure 8: Effects of 10% reduction in variable costs on TVC, by production system (%)

For semi-zero grazers, the largest decrease in TVC would result from a 10% reduction in feed concentrate costs (3.8%), followed by hired labour (2.3%) and health & breeding costs (2.0%). However, these effects vary across counties within this production system. For example, in small-scale semi-zero grazing, the largest reduction in TVC (8.0%) would occur in Baringo if feed concentrate costs were reduced by 10% (Table A17). The highest decline in TVC due to a reduction in health and breeding would occur in Bungoma (6.9%). In Migori and Kisii, a 10% decrease in hired labour costs would lower TVC by approximately 5.8% and 3.6%, respectively. In medium scale semi-zero grazing, the most significant reduction in TVC (5.1%) would come from a decrease in hired labour costs in Bomet (Table A18).

For open grazers, a 10% reduction in hired labour would result in the highest decline in TVC at 5.1%, followed by a 2.8% reduction from feed concentrate costs, with the impact being greater for medium-scale producers (Table A19).

3.1.8 Key factors in improving gross margin

We simulate the effect of a 10% reduction in key cost components (feeds, pasture, health & breeding, and hired labour) on GM, with each component adjusted separately while keeping

other costs constant. A 10% reduction in feed concentrate costs would lead to an increase in GM of 4.4% for zero grazers, 1.8% for semi-zero grazers, and 0.6% for open grazers (Figure 9). Similarly, a 10% reduction in hired labour costs would boost GM by 1.9% for zero grazers and 0.1% for semi-zero grazers and open grazers. (Figure 9).

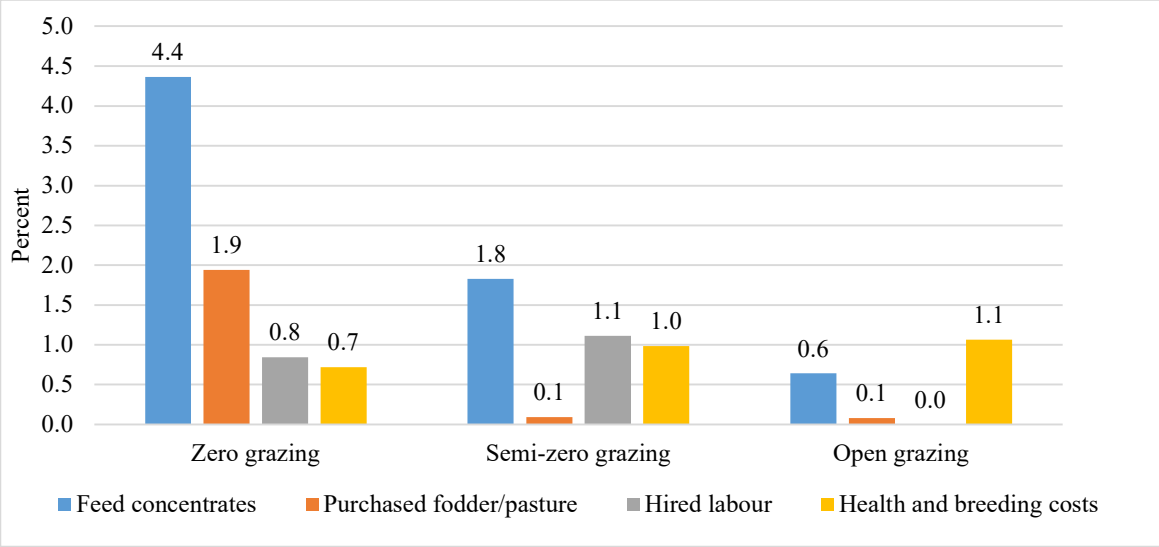

Figure 9: Effect of 10% reduction in variable costs on gross margin by production system

3.2 Model dairy farms

3.2.1 Production characteristics of model dairy farms in the study areas

Production characteristics of model dairy farms in the study counties are presented by production system in Table 15. In contrast to other model farms, the two farms in the zero grazing-2 category had much larger herd sizes and higher number of lactating cows compared to the model farms in the zero grazing-1, semi-zero grazing and open grazing categories. Overall, about 46-53 percent of the dairy herd in the model farms were cows, majority (60-83%) of which were lactating. The average milk yield per cow per day in the model farms ranged between 14 and 23 litres, with the model farms in the zero grazing-2 category yielding the highest (23 litres), and the open grazing farm yielding the lowest (9.5 litres). Similar to the typical farms, zero grazing model farms had the highest milk yield, while their open grazing counterparts had the lowest yield.

Cooperative societies were the main buyers of milk from the model farms, offering between KES 35 and KES 55 per litre of milk. The one model farm in the zero grazing-2 category that sold milk to a processor received KES 65 for a litre of milk.

Table 15: Characteristics of a dairy farm by production system in Kenya (Model Farm)

Item	Zero grazing-1 (n=17)	Semi-zero grazing (n=10)	Open grazing (n=1)	Zero grazing[5]-2 (n=2)
Average herd size	13	10	18	78
Average number of cows	6	5	9	41
Average number of lactating cows	5	3	7	34
Proportion of lactating cows in herd size (%)	38	30	39	44
Average annual milk production	27,634	12,270	19,950	237,870
Average annual yield (litres/cow/year)	5,527	4,231	2,850	6,996
Average daily yield (litres/cow/day)	18.4	14.1	9.5	23.3
Proportion of milk sold (%)	87	85	89	95
Average price per litre by main buyer in 2024 (KES)	48.7	43.0	35.0	60.0
Main buyer	Coop	Co-op	Co-op	Processor/Coop

3.2.2 Production characteristics of a model dairy farm by production system and county

a) Zero grazing

Table 16 shows the characteristics of five small scale zero grazing model dairy farms (one in each county). On average, a small scale zero grazing model farm had 3 lactating cows, each producing an average of 17 litres of milk per day, translating to 5,012 litres of milk per cow per year. Friesian was the dominant cow breed in the herd. Co-operative societies were the main buyers of milk from these farms, offering farmers between KES 44 and 63 per litre of milk. In Nakuru, however, a trader was the main milk buyer from the model farm and offered the farmer a price within the range of the price offered by cooperatives.

For medium scale zero grazing model dairy farms, the number of lactating cows averaged 6, each producing an average of 21.3 litres of milk per day (or 6,391 litres per year) (Table 17). Cooperative societies were the main buyers of milk. The producer price offered by the main buyers ranged between KES 40 and KES 50 per litre of milk, with the medium scale farmer in Meru reporting the highest price (about KES 55) and the farmers in Uasin Gishu and Trans Nzoia reporting the lowest price of KES 40 per litre of milk. Nine out of the twelve model farms kept Friesian cows, the model farm in Baringo kept Jersey, while those in Uasin Gishu and Trans Nzoia kept Ayrshire.

[5] Separate analyses of the zero-grazing production system data were conducted; small and medium-sized farms make up zero grazing-1, whereas two large-scale farms make up zero grazing-2.

Table 16: Characteristics of a zero grazing model dairy farm (small-scale)

Characteristic	County					Average (SS)
	Embu (n=1)	Kajiado (n=1)	Machakos (n=1)	Nakuru 2 (n=1)	Nyandarua (n=1)	
Scale of production	SS	SS	SS	SS	SS	
Average herd size	8	5	6	10	5	7
Average number of cows	4	2	4	6	3	4
Average no. of lactating cows	3	1	3	4	3	3
Proportion of lactating cows to herd size (%)	38	20	50	40	60	43
Dominant breed	Friesian	Friesian	Friesian	Friesian	Friesian	
Average milk production (litres/year)	16,560	6,285	9,420	22,290	13,620	13,635
Average daily milk yield (litres/cow/day)	18.4	21.0	10.5	18.6	15.1	16.7
Average milk yield (litres/cow/year)	5,520	6,285	3,140	5,573	4,540	5,012
Proportion of milk sold (%)	79	88	94	85	93	88
Average price per litre by main buyer in 2024 (KES/litre)	47.0	58.3	63.3	44.3	43.5	51.3
Main buyer	Dairy Coop	Dairy Coop	Dairy Coop	Trader	Dairy Coop	

Table 17: Characteristics of a zero grazing model dairy farm (medium scale)

Characteristic	County												
	Baringo (n=1)	**Kericho (n=1)**	**Kiambu (n=1)**	**Kirinyaga (n=1)**	**Meru (n=1)**	**Murang'a (n=1)**	**Nyeri 1 (n=1)**	**Nyeri 2 (n=1)**	**Taita Taveta (n=1)**	**Uasin Gishu (n=1)**	**Trans Nzoia (n=1)**	**Nandi (n=1)**	**Average (MS)**
Scale of production	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
Average herd size	22	6	17	13	23	23	10	6	10	21	15	20	16
Average number of cows	11	5	7	6	9	12	5	5	3	10	6	7	7
Average no. of lactating cows	7	5	7	6	9	10	4	3	3	8	4	5	6
Proportion of lactating cows to herd size (%)	32	83	41	46	39	43	40	50	30	38	27	25	38
Dominant breed	Jersey	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Ayrshire	Ayrshire	Friesian	
Average milk production (litres/year)	52,920	33,240	39,000	33,600	36,900	67,800	21,960	25,200	13,680	44,100	40,680	31,500	36,715
Average daily milk yield (litres/cow/day)	25.2	22.2	18.6	18.7	13.7	22.6	18.3	28.0	15.2	18.4	33.9	21.0	21.3
Average annual milk yield (litres/cow/year)	7,560	6,648	5,571	5,600	4,100	6,780	5,490	8,400	4,560	5,513	10,170	6,300	6,391
Average value of annual milk production	2,157,141	1,519,200	1,929,323	1,646,400	2,091,000	3,391,500	988,200	1,159,200	680,040	1,764,000	2,469,600	1,407,000	1,766,884
Proportion of milk sold (%)	75	86	96	86	92	91	86	89	85	77	92	85	87
Gross revenue from milk (sold +consumed)	40.8	45.7	49.5	49.0	61.5	56.7	50.0	44.7	46.0	45.0	49.7	60.7	40.0
Average price per litre by main buyer in 2024 (KES/litre)	41.1	46.7	49.9	49.0	55.0	49.3	45.0	50.0	43.0	40.0	40.0	50.0	46.6
Main buyer	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	Dairy Coop	School	Dairy Coop	Dairy Coop	Consumers	Consumers	

There were two large-scale model farms in the zero grazing production system: one in Nakuru and another in Tharaka Nithi (Table 18). These farms had an average of 34 lactating cows, each producing an average of 23 litres of milk per day (7,005 litres per year). The farm in Nakuru sold milk to a processor at an average price of KES 60 per litre while that in Tharaka Nithi sold milk mainly to a cooperative society, which offered KES 55 per litre of milk. Both farms had Friesian as the main breed of cows.

Table 18: Characteristics of a zero grazing model dairy farm (large-scale)

Characteristic	County		
	Nakuru 1 (n=1)	Tharaka Nithi (n=1)	Average (LS)
Scale of production	LS	LS	
Average herd size	78	78	78
Average number of cows	38	43	41
Average no. of lactating cows	38	30	34
Proportion of lactating cows to herd size (%)	49	38	44
Dominant breed	Friesian	Friesian	
Average annual milk production (litres/year)	263,340	212,400	237,870
Average daily milk yield (litres/cow/day)	23.1	23.6	23.4
Average annual milk yield (litres/cow/year)	6,930	7,080	7,005
Proportion of milk sold (%)	98	93	95
Average price per litre by main buyer in 2024 (KES/litre)	65.0	55.0	60.0
Main buyer	Processor	Dairy Coop	

b) Semi-zero grazing

Table 19 shows the characteristics of the 7 small scale semi-zero grazing model farms included in this study. On average, a small scale semi-zero grazing model farm had 2 lactating cows, each producing an average of 15.2 litres of milk per day (or 7,985 litres per year). One of the farms in Kiambu (Lari-1) had the highest milk yield per day (29 litres), while the farm in Kisii had the least yield (6.6 litres). The average price per litre of milk offered by the main buyer ranged between KES 35 (in Bungoma) and KES 75 (in Kakamega). Three model farms (in Bungoma, Migori and Nyeri) sold most of their milk to co-operatives, while five model farms sold to consumers or traders. The model farms mostly kept Friesian cows, except the farm in Bungoma that kept Ayrshire cows.

Table 19: Characteristics of a semi-zero grazing model dairy farm (small scale)

Characteristic	County							
	Bungoma (n=1)	**Kakamega (n=1)**	**Kiambu-Lari 1 (n=1)**	**Kiambu-Lari 2 (n=1)**	**Kisii (n=1)**	**Migori (n=1)**	**Nyeri-Kieni (n=1)**	**Average (SS)**
Scale of production	SS	SS	SS	SS	SS	SS	SS	
Average herd size	8	4	5	4	8	4	5	6
Average number of cows	3	3	3	2	3	2	2	3
Average no. of lactating cows	2	3	1	2	3	1	2	2
Proportion of lactating cows to herd size (%)	25	75	20	50	38	25	40	33
Dominant breed	Ayrshire	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	
Average annual milk production (litres/year)	9,300	11,580	8,700	5,910	7,920	4,500	8,550	7,985
Average daily milk yield (litres/cow/day)	15.5	12.9	29.0	9.9	8.8	15.0	14.3	15.2
Average annual milk yield (litres/cow/year)	4,650	3,860	8,700	2,955	2,640	4,500	4,275	4,551
Proportion of milk sold (%)	79	92	82	83	91	87	72	86
Average price per litre by main buyer in 2024 (KES/litre)	35.0	75.0	48.0	47.0	50.0	47.0	41.7	50.3
Main Buyer	Dairy Coop	Consumer	Trader/ broker	Broker	Broker	Dairy Coop	Dairy Coop	

The characteristics of the three semi-zero grazing medium scale model farms are presented in Table 20. These farms had an average of 5 lactating cows each producing an average of 14.2 litres of milk per day (4,270 litres per year). The farm in Bomet produced the highest milk per cow per day (17.6 litres), while the farm in Narok had the lowest milk yield (9.2 litres). The price of milk per litre received by the medium scale farms ranged between KES 38 (Elgeyo Marakwet) and KES 55 (Narok). The farm in Bomet and that in Narok sold milk mainly to cooperative societies, while that in Elgeyo Marakwet sold to hotels. All the three model farms kept the Ayrshire breed, which adapts better in various agro-ecological zones, is more efficient in feed conversion and can do relatively well with lower quality feeds. This points to the need for farmers to consider keeping breeds that are suitable for specific agro-ecological zones, and which have desirable traits such as efficient conversion of forage material into milk. This may lead to higher milk yields at relatively lower costs.

Table 20: Characteristics of a semi-zero grazing model dairy farm (medium scale)

Characteristic	County			
	Bomet (n=1)	**Elgeyo Marakwet (n=1)**	**Narok (n=1)**	**Average (MS)**
Scale of production	MS	MS	MS	
Average herd size	18	28	12	19
Average number of cows	7	18	6	10
Average no. of lactating cows	2	10	3	5
Proportion of lactating cows to herd size (%)	11	36	25	26
Dominant breed	Ayrshire	Ayrshire	Ayrshire	
Average annual milk production (litres/year)	10,560	47,700	8,280	22,180
Average daily milk yield (litres/cow/day)	17.6	15.9	9.2	14.2
Average annual milk yield (litres/cow/year)	5,280	4,770	2,760	4,270
Proportion of milk sold (%)	92	89	80	87
Average price per litre by main buyer in 2024 (KES/litre)	41.7	38.0	55.0	44.9
Main Buyer	Dairy Coop	Hotels	Dairy Coop	

Open grazing production system was practised on one model farm in West Pokot (Table 21). The farm had 7 lactating cows of mainly Friesian breed, with each producing an average of 9.5 litres of milk per day (2,850 litres per year). It sold milk mainly to a cooperative society, which offered KES 35 per litre.

Table 21: Characteristics of an open grazing model dairy farm

Characteristic	County
	West Pokot (n=1)
Scale of production	MS
Average herd size	18
Average number of cows	9
Average no. of lactating cows	7
Proportion of lactating cows to herd size	39%
Dominant breed	Friesian
Average annual milk production (litres/year)	19,950
Average daily milk yield (litres/cow/day)	9.5
Average annual milk yield (litres/cow/year)	2,850
Proportion of milk sold (%)	89%
Average price per litre by main buyer in 2024 (KES/litre)	35.0
Main buyer	Dairy Coop

3.2.3 Costs and margins in milk production in model farms

3.2.3.1 Costs and margins in milk production by production system

The costs and margins per litre of milk produced for the model farms for each production system, are presented in Table 22. The gross revenue per litre of milk ranged between KES 39.2 and KES 60, with the two large scale zero grazing farms (zero grazing-2) receiving the highest revenue per litre of milk, while the only open grazing model farm received the lowest gross revenue per litre of milk. The average gross revenue per litre of milk for the small scale zero grazing model farms (zero grazing-1) was similar to that of the small scale zero grazing typical farms, which was KES 49.3. For open grazers and semi-zero grazers, the average revenue per litre of milk was higher for the model farms compared to their counterparts in the typical category.

On average, total variable cost (TVC) and total cost (TC) were highest in zero grazing farms and lowest for the open grazing farm. The TVC per litre of milk in model farms was higher than in typical farms by about KES 2.8 per litre (for zero grazing system), KES 2 (for semi-zero grazing system) and KES 6 (for open grazing system).

For gross margin per litre of milk, small scale zero grazing model farms had the lowest margin (KES 22.8), while the open grazing farm had the highest margin (KES 36.7). Compared to the typical farms, the average gross margins were higher in the model farms than the typical farms, except for small scale zero grazers where typical farms had higher average gross margin than model farms. Overall, the positive gross margins for the model farms indicate that the farms were able to cover all their variable costs.

Table 22: Average costs and margins per litre of milk production, by production system

	Zero grazing-1 (n=17)	Semi-zero grazing (n=10)	Open grazing (n=1)	Zero grazing-2 (n=2)
Gross value of milk produced (sold +consumed + fed to calves)	**49.4**	**52.0**	**39.2**	**60.0**
Value of milk sold	43.0 (87)	44.2 (85)	34.9 (89)	57 (95)
Value of milk consumed	3.9 (8)	5.7 (11)	3.9 (10)	0.6 (1)
Value of milk given to calves	2.5 (5)	2.1 (4)	0.4 (1)	2.4 (4)
Purchased fodder/pasture	2.9	0.7	0.0	0.8
Feed concentrates	12.8	5.3	0.0	15.3
Mineral salts	1.9	1.7	0.2	1.7
Water (purchased)	0.3	0.1	0.0	0.03
Health and breeding costs	1.6	3.1	0.9	1.0
Milking jelly	0.2	0.2	0.1	0.2
Hired labour	5.9	5.3	0.0	9.5
Repairs on fixed assets	0.5	0.5	1.3	0.3
Other costs (e.g. electricity, fuel)	0.5	0.2	0.0	0.4
Total variable costs (TVC)	**26.6**	**17.1**	**2.5**	**29.5**
Gross margin (revenue - TVC)	**22.8**	**34.9**	**36.7**	**30.5**
Depreciation (fixed assets)	1.8	0.9		0.5
Own fodder/pasture	10.7	13.6	17.5	13.7
Family labour	5.0	7.7	4.2	0.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	**44.1**	**39.3**	**24.2**	**43.4**
Milk profits (revenue - TC)	**5.2**	**12.7**	**15.0**	**16.6**
Other revenue (sale of livestock, manure, bull services)	7.5	2.6	14.4	5.9
Whole enterprise profit	**12.8**	**15.3**	**29.4**	**22.5**
Gross margin/TVC ratio	1.1	2.0	14.7	1.0
Gross margin rate (%)	45.4	67.1	93.6	50.6

The total cost averaged KES 44.1 among the small-scale zero-grazing model farmers, which was higher than the KES 39.3 and KES 24.1, respectively, for semi-zero grazers and the open grazing farm. The latter had the highest milk and whole enterprise profits, followed by semi-zero grazing farms and, lastly, the small-scale zero-grazing farms.

The ratio of gross margin to TVC averaged KES 1 for both small-scale and large-scale zero-grazing model farms, which means that these farms earned KES 1 for every shilling they spent on variable costs to produce one litre of milk. The open grazing farm generated KES 14.7 in gross margin for every KES 1 spent on variable costs, indicating that the open grazing model farm generated a much higher return relative to its variable costs compared to the other model farms and typical farms. The average gross margin rate ranged between 45.4% (small-scale zero grazing) and 93.6% (open grazing).

3.2.3.2 Costs and margins of milk production by production system and county

a) ***Zero grazing***

Costs and margins for the five small scale zero grazing model farms (one in each county) are presented in Table 23. The farm in Machakos had the highest gross revenue per litre of milk (KES 61.5) while the one in Nakuru had the lowest (KES 44). The farms in Embu and Nakuru

had the lowest total variable cost (KES 19.6), while those in Nyandarua had the highest cost (KES 38.1), mainly driven by the cost of feed concentrates.

The farm in Kajiado had the highest gross margin (KES 36.2) among the five model farms, but that margin was lower than for the typical small-scale zero-grazing farm in Kajiado (KES 43.7). The situation was different in Embu and Machakos, where the model farm's gross margin was higher than the average gross margin for the corresponding small-scale zero-grazing typical farms in the counties.

The model farm in Machakos incurred the highest total cost (KES 66.9), followed by Kajiado (KES 50.8) and Nyandarua (KES 52.4). In Machakos and Kajiado, the total cost was higher than the average total cost for the corresponding typical farms, while in Embu the average total cost for small scale zero grazing typical farms was lower than for the model farm. Small scale zero grazing model farms in Machakos and Nyandarua made economic losses of KES 5.4 and KES 8.9, respectively. It is worth noting that the two farms did not have revenue from sale of products such as livestock or manure. The losses could be due to specific farm inefficiencies, transitory setbacks or external factors. The farm in Kajiado made a relatively higher whole enterprise profit (KES 20.4) after including revenue from other products.

For every shilling invested in variable costs to produce a litre of milk, the farm in Kajiado had the highest return of KES 1.6, while the farms in Kiambu and Nyandarua had the lowest returns of KES 0.7 and KES 0.6, respectively.

Table 23: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (small-scale)

County	Embu	Kajiado	Machakos	Nakuru 2	Nyandarua
Gross revenue from milk (sold +consumed)	53.5	58.9	61.5	44.0	43.5
Total variable costs (TVC)	19.6	22.7	36.4	19.6	38.1
Gross margin (revenue - TVC)	33.9	36.2	25.1	24.4	5.4
Total costs (TC = TVC + depreciation + own labour + own fodder)	40.7	50.8	66.9	36.8	52.4
Milk profits (revenue - TC)	12.8	8.1	-5.4	7.3	-8.9
Total costs (TC = TVC + depreciation + own labour + own fodder)	40.7	50.8	66.9	36.8	52.4
Whole enterprise profit	15.1	20.4	-5.4	7.3	-8.9
Gross margin/TVC ratio	1.7	1.6	0.7	1.2	0.1
Gross margin rate (%)	63.3	61.5	40.8	55.4	12.5

Note: Full results are shown in Table A6 in the Appendix

Table 24 shows costs and margins for 12 medium scale zero grazing model farms from 11 counties. The farm in Trans Nzoia had the highest gross revenue (KES 60.7), while that in Uasin Gishu had the lowest (KES 40). While the farm in Baringo had the lowest TVC (KES 11.6), the one in Kirinyaga had the highest (KES 33.6). Feed concentrates were the main drivers of the high TVC in Kirinyaga.

The model farm in Trans Nzoia had the highest gross margin (KES 47.4) followed by the farms in Meru (KES 34.3) and Baringo (KES 29.2), whereas the farm in Nyeri-Mukurweini had the lowest gross margin of KES 8.6 per litre of milk.

The farm in Nyeri-Kieni had the highest total cost (KES 48.8) and made economic losses, followed by the farms in Meru (KES 46.8) and Murang'a (KES 45.7). Model farms in Kajiado and Meru made relatively higher whole enterprise profits than the other farms.

For every shilling invested in variable cost to produce a litre of milk, the farm in Trans Nzoia had the highest returns (KES 3.6) while that in Nyeri-Mukurweini had the lowest returns (KES 0.2). Gross margin rate was highest in Kajiado (78.1%) and lowest in Nyeri-Mukurweini.

Table 24: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (Medium scale)

County	Baringo	Kericho	Kiambu	Kirinyaga	Meru	Murang'a	Nandi	Nyeri-Kieni	Nyeri-Mukurweini	Taita Taveta	Trans Nzoia	Uasin Gishu
Gross revenue from milk (sold +consumed)	40.8	45.7	49.5	49.0	56.7	50.0	44.7	46.0	45.0	49.7	60.7	40.0
Total variable costs (TVC)	11.6	22.6	31.5	37.8	22.3	33.6	24.2	27.9	36.4	31.5	13.3	22.4
Gross margin (revenue - TVC)	29.2	23.1	17.9	11.2	34.4	16.4	20.5	18.1	8.6	18.2	47.4	17.6
Total costs (TC = TVC + depreciation + own labour + own fodder)	38.8	32.2	44.0	40.7	46.8	45.7	44.0	48.8	40.6	44.2	40.1	35.6
Milk profits (revenue - TC)	1.9	13.5	5.5	8.3	9.9	4.3	0.6	-2.8	4.4	5.5	20.6	4.4
Whole enterprise profit	9.2	19.8	20.7	24.7	38.7	14.3	5.9	-2.8	7.9	5.5	40.6	5.2
Gross margin/TVC ratio	2.5	1.0	0.6	0.3	1.5	0.5	0.8	0.7	0.2	0.6	3.6	0.8
Gross margin rate (%)	71.6	50.6	36.3	22.9	60.7	32.8	45.8	39.4	19.0	36.7	78.1	44.1

Note: Full results are shown in Table A7 in the Appendix

The costs and margins for the two large scale zero grazing model farms in Nakuru and Tharaka Nithi are presented in Table 25. The gross revenue per litre of milk for these farms was higher than that for most of the medium scale and small scale zero grazing model farms. Their TVC were KES 29.9 and KES 29, respectively. The farm in Nakuru had 1.4 times the gross margin for the farm in Tharaka Nithi. Its total cost was also slightly higher. The main driver of total costs for both farms was the cost of own fodder. The farm in Nakuru had higher milk profit, which may be due to the higher price per litre of milk. It also had higher gross margin/TVC ratio and gross margin rate.

Table 25: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (large scale)

Production system	**Zero Grazing**	
County	**Nakuru 1**	**Tharaka Nithi**
Gross revenue from milk (sold +consumed)	65.0	55.0
Total variable costs (TVC)	**29.9**	**29.0**
Gross margin (revenue - TVC)	35.1	26.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	**44.3**	**42.5**
Milk profits (revenue - TC)	20.7	12.5
Whole enterprise profit	29.7	15.3
Gross margin/TVC ratio	1.2	0.9
Gross margin rate (%)	54.0	47.2

Note: Full results are shown in Table A8 in the Appendix

b) Semi-zero grazing

The costs and margins for the small-scale model farms in the semi-zero grazing production system are presented in Table 26. The farm in Kakamega had both the highest gross revenue and total variable cost per litre of milk, while that in Nyeri-Kieni had the lowest of both.

Reflecting the highest gross revenue, the farm in Kakamega had the highest gross margin per litre of milk (KES 47.5) (but was lower than the gross margin for the small scale semi-zero grazing typical farm in the county), while the farm in Migori county had the lowest gross margin (KES 22.8). The highest total cost was recorded by the model farm in Kiambu Lari-2, which was driven mainly by the cost of own fodder/pasture.

Similar to the small scale semi-zero grazing typical farms in Bungoma, the model farm in this county had the highest total cost, mainly driven by the costs of family labour and own fodder/pasture, which caused the farm to incur an economic loss KES 3.2. The model farm in Kakamega reported the highest milk profits (KES 38.4), which was 1.4 times the average profit of small scale semi-zero grazing typical farms in the county, despite the two groups of farms facing the same average price of milk. This indicates that the small scale semi-zero grazing model farm in Kakamega was more efficient. The model farm in Kiambu Lari-2 made economic loss of KES -6.6. The highest gross margin/TVC ratio and gross margin rate were reported by the model farm in Kiambu Lari-1. The key difference for the two farms is that Lari-2 had higher TVC and TC, which was mainly due to high cost of feed concentrate and the cost

of own fodder/pasture. This may reflect disparities in management practices, resource utilization, and operational efficiencies.

Table 26: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing model farms (small-scale farms)

County	Bungoma	Kakamega	Kiambu-Lari 1	Kiambu-Lari 2	Kisii	Migori	Nyeri-Kieni 1
Gross revenue from milk (sold +consumed)	48.4	75.0	48.9	47.0	50.0	47.0	40.9
Total variable costs (TVC)	16.3	27.5	12.2	22.6	14.1	24.2	11.7
Gross margin (revenue - TVC)	32.1	47.5	36.6	24.4	35.9	22.8	29.2
Total costs (TC = TVC + depreciation + own labour + own fodder)	51.6	36.6	34.9	53.6	33.9	32.12	38.9
Milk profits (revenue - TC)	-3.2	38.4	14.0	-6.6	16.1	14.9	2.0
Whole enterprise profit	-3.2	41.0	16.1	-6.6	16.1	14.9	20.1
Gross margin/TVC ratio	0.7	1.7	3.0	1.1	2.5	0.9	2.5
Gross margin rate (%)	66.4	63.3	75.0	51.9	71.8	48.4	71.4

Note: Full results are shown in Table A9 in the Appendix

Results for the three medium scale model farms under the semi-zero grazing production system are presented in Table 27. The farm in Elgeyo Marakwet had the highest milk revenue (KES 71.4) and TVC (KES 18.3), while that in Bomet had the lowest of both. Additionally, the farm in Elgeyo Marakwet recorded the highest gross margin (KES 53.1), while that in Bomet had the lowest gross margin (KES 27.4). The farm in Narok incurred the highest total cost per litre of milk (KES 41.9), with family labour and own fodder/pasture driving up the cost. The farm in Elgeyo Marakwet had the highest milk and whole enterprise profits. However, the farm in Narok had the highest gross margin/TVC ratio and gross margin rate.

Table 27: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing model farms (medium-scale farms)

County	Bomet	Elgeyo Marakwet	Narok
Gross revenue from milk (sold +consumed)	39.1	71.4	52.4
Total variable costs (TVC)	11.7	18.3	12.3
Gross margin (revenue - TVC)	27.4	53.1	40.1
Total costs (TC = TVC + depreciation + own labour + own fodder)	30.8	39.1	41.9
Milk profits (revenue - TC)	8.3	32.2	10.5
Whole enterprise profit	11.1	33.0	10.5
Gross margin/TVC ratio	2.3	2.9	3.3
Gross margin rate (%)	70.0	74.4	76.6

Note: Full results are shown in Table A10 in the Appendix

c) Open grazing

There was only one model farm in West Pokot practising open grazing. This farm had milk revenue of KES 39.2 per litre, which was slightly higher (by KES 5.6) than that of the typical farm in the same county. Additionally, the TVC of the model farm (KES 2.5) was lower than

the TVC of the typical farm (KES 4.8). The farm's total cost of producing a litre of milk was KES 24.3, which was less than the average total cost of the typical farm (KES 28.8). Milk profits and whole enterprise profits for the model farm were higher than for the typical farms. The gross margin/TVC ratio and gross margin rate were also higher than for the typical farm.

Table 28: Summary of costs and margins (KES) per litre of milk production for open grazing model farms

Production system	**Open Grazing**
County	**West Pokot**
Gross revenue from milk (sold +consumed)	39.2
Total variable costs (TVC)	2.5
Gross margin (revenue - TVC)	36.7
Total costs (TC = TVC + depreciation + own labour + own fodder)	24.3
Milk profits (revenue - TC)	14.9
Whole enterprise profit	29.4
Gross margin/TVC ratio	14.7
Gross margin rate (%)	93.6

Note: Full results are shown in Table A11 in the Appendix

3.2.4 Relative contribution of inputs to the total cost of milk production

The shares of different input categories in total cost of production for model farms in different production systems are presented in Figure 10. Feeds and labour accounted for the largest share of the total cost of producing a litre of milk across all the production systems. Feeds contributed 65%, 54.2% and 73.1% of the total cost in the zero, semi-zero and open grazing system, respectively. The share of labour in total cost was highest in semi-zero grazing system (33.0%) and lowest in the open grazing system. The cost share of health management and breeding were highest (8.4%) in semi-zero grazing system and lowest (4%) in zero grazing and open grazing systems.

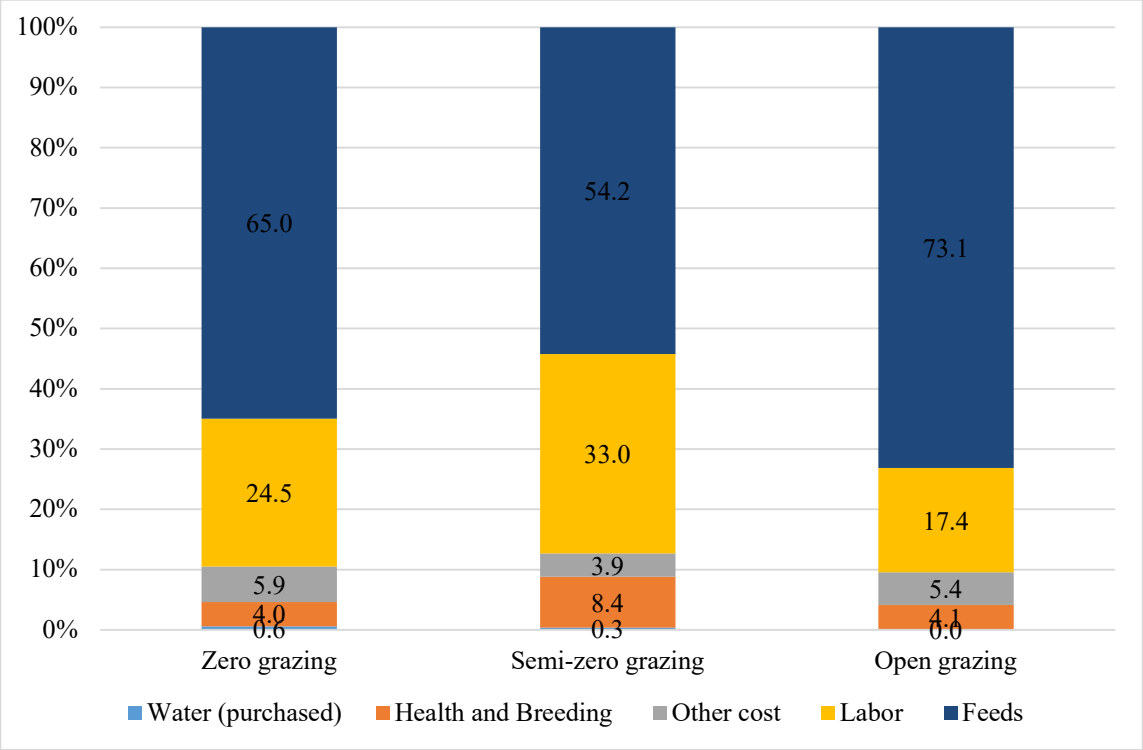

Figure 10: Share of inputs in total cost of production, by production system - model farm (%)

The cost share of various inputs in TVC across the three grazing systems (zero**,** semi-zero grazing**,** and open grazing) are presented in Figure 11. The results reveal key insights into how each system allocates resources, and where potential cost-saving or efficiency improvement measures could be targeted. For zero grazing, feed concentrates dominate the cost of production, accounting for nearly half (48.6%) of TVC. This is expected in zero grazing systems where cows are confined, and their diet heavily relies on purchased feed. Hired labour is the second-largest cost component (23.4%), while purchased fodder (10.1%) and other inputs (mineral salts, health management & breeding costs) make up the remaining portion, with the share of animal health management costs being relatively low (5.9%). Since feed concentrates represent a major share of costs, a small reduction in the cost of feeds can be expected to significantly impact overall profitability. Efforts to reduce reliance on purchased feeds or sourcing cheaper alternatives could yield substantial gains. Reducing hired labour costs, possibly through automation or better management practices, would also contribute to improving gross margins.

The cost distribution in semi-zero grazing is more balanced between feed concentrates (31.2%) and hired labour (30.9%). The share of health management and breeding costs (18.2%) are higher than in the zero grazing system, reflecting the more exposed nature of cattle in this system to pest and disease risk. Purchased fodder (9.8%) and mineral salts (4.1%) also contributed significantly, but not as much as the top three categories. Cost-cutting efforts could target both feed and labour. A balanced approach—optimizing labour efficiency while reducing feed costs—could yield significant improvements in profitability. The relatively high share of health management and breeding costs (18.2%) suggests that improving herd health and

reducing veterinary expenses (through preventive measures or better herd management) could also have a notable impact on cost savings.

The cost structure in open grazing system is distinct from the other systems, with repair of fixed assets (mainly repair of paddock fence) accounting for the largest share (52.0%) of cost, followed by health management and breeding costs (36.0%). Mineral salts (8.0%) also form a substantial share of the TVC. Focusing on reducing health management costs through preventive care and better breeding practices could lead to better financial outcomes for the farmers in this production system.

Overall, each grazing system has unique cost challenges. Open grazing faces the highest costs in health and repairs, while zero and semi-zero grazing are more dependent on labour and feed concentrates. Tailored interventions, such as improving animal health management, reducing feed costs, and optimizing labour, could significantly increase profitability across these systems.

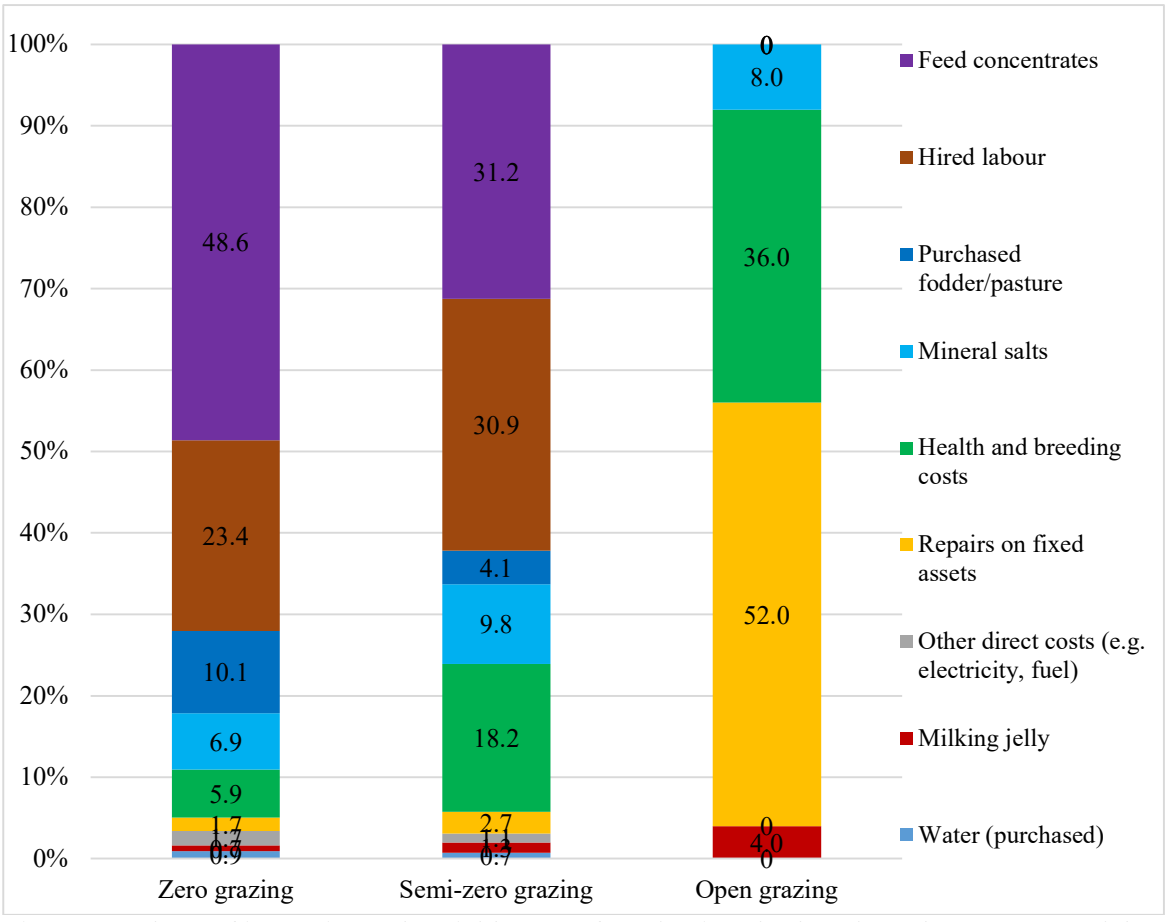

Figure 11: Share of inputs in total variable cost of production- broken down by source- model farm (%)

The cost share of inputs in total cost (TC) varied across the production systems, similar to the share of inputs in TVC (Figure 12). For the zero grazers, the largest share in TC were feed concentrates (29.5%) followed by own fodder/pasture (25%), whereas for semi-zero grazing system, own fodder/pasture (34.6%) and family labour (19.6%) had the largest share. For

open grazers, the largest components of TC were own fodder/pasture (72.3%) and family labour (17.4%).

Overall, labour accounted for 24.5%, 33.1% and 17.4% of total costs for zero, semi-zero and open grazers, respectively. In assessing the labour efficiency across different dairy production systems, it is evident that semi-zero grazing, with an average herd size of 10 cows, demonstrated significant inefficiencies compared to zero grazing (13 cows) and open grazing (18 cows). The relatively smaller herd size in semi-zero grazing vis a vis the share of labour in total cost in comparison to other production systems may suggest overutilization of labour and higher unit labour costs per litre of milk produced. A critical factor contributing to this inefficiency is farmers' tendency to undervalue family labour (and other non-purchased inputs), which often results in excessive use of own labour on farms. Furthermore, many family members, lacking off-farm employment, spend considerable time on the farm. Recognizing and accurately valuing family labour used on own farm could empower farmers to make more informed decisions about labour allocation and resource management, ultimately improving efficiency.

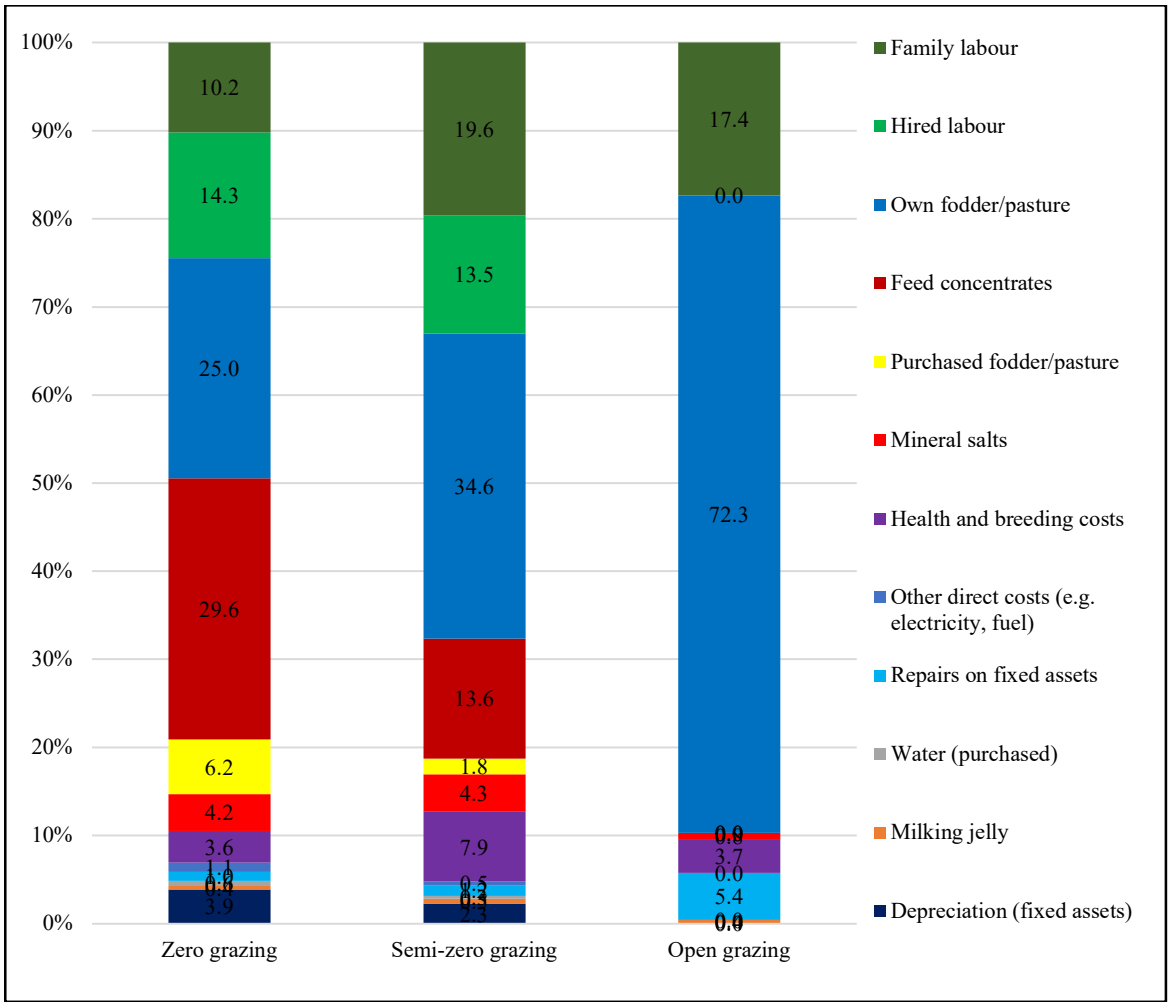

Figure 12: Share of inputs in total cost of production- broken down by source- model farm (%)

3.2.5 Costs and margins of milk production per lactating cow

Milk production margins per lactating cow can be used as a proxy for efficiency. The costs and margins per lactating cow are presented in Figure 13. Farms in the zero grazing system had the highest gross revenue (KES 308,120) per lactating cow while those in the open grazing had the lowest gross revenue (KES 111,750). However, the average gross revenue for model farms was generally higher than for the typical farms.

The TVC and TC were highest for farms in the zero grazing production system and lowest for those in the open grazing system. Farmers in the open grazing had the lowest average gross margin per lactating cow (KES 64,013) while those in the zero grazing system had the highest average gross margin (KES 150,585). However, the model farms practising semi-zero grazing had the highest milk profits per lactating cow (KES 58,048) while open grazers had the least (KES 42,567). On average, whole enterprise profit per lactating cow was highest in the zero grazing system (KES 91,656) and lowest in the semi-zero grazing system (KES 83,710).

The costs and margins per lactating cow among typical farms across production systems and county are in the Appendix (Figure A6, Figure A7, Figure A8, Figure A9, and Figure A10).

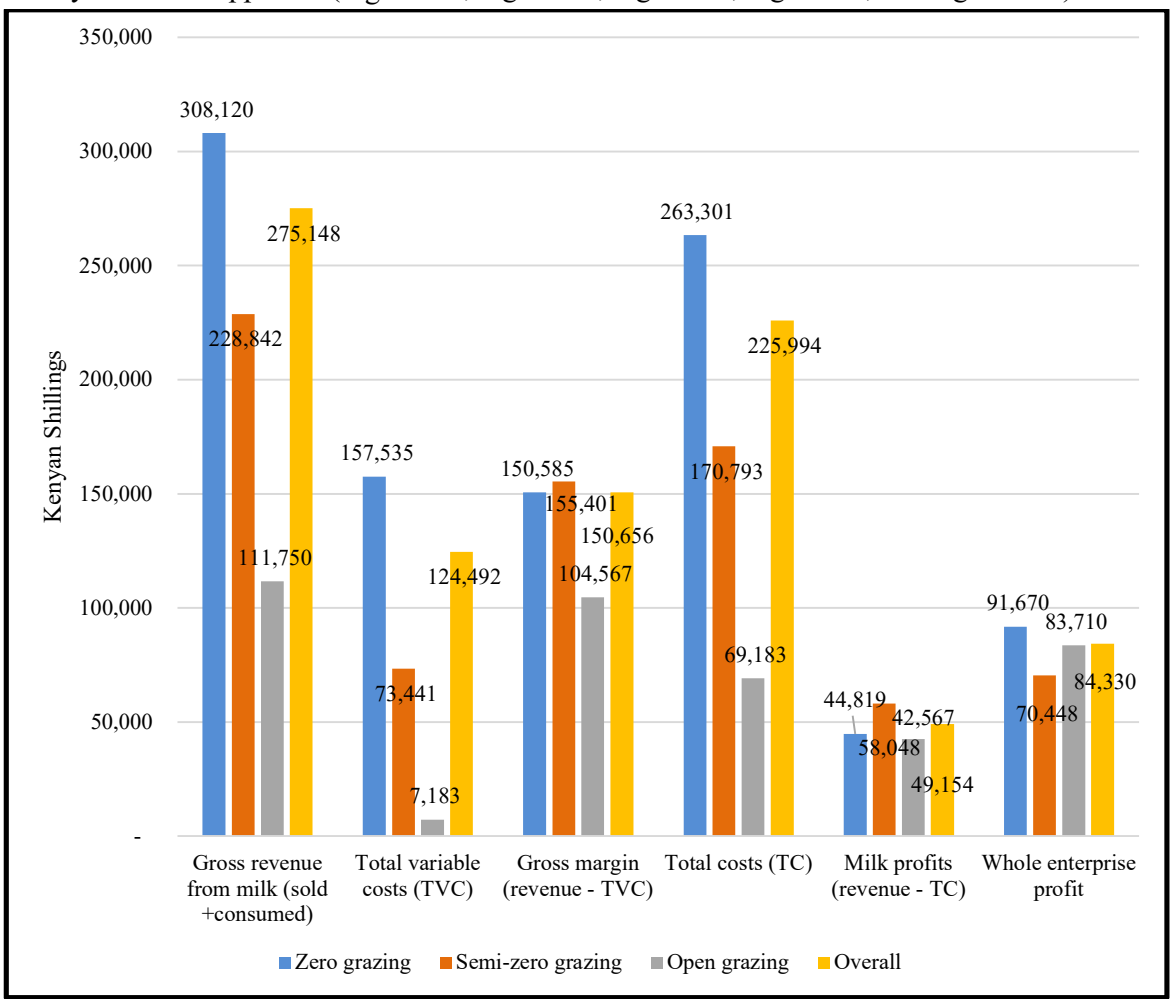

Figure 13: Costs and margins (KES) per lactating cow, by production system (model farms)

3.2.6 Comparison of typical and model farms and break-even levels of milk production

Table 29 compares typical and model farms and estimates the milk production levels each type of farm needs to reach to break even.

There were variations in the average production costs and margins between model and typical farms. Relative to their counterparts in the typical farm category:

- Zero and open-grazing model farms had more lactating cows
- All three production systems in the model farm category had higher milk yield
- Zero and semi-zero grazing model farms had higher TVC
- Gross margin, milk profit and whole enterprise profit were higher for semi-zero and open grazing but lower for zero grazing model farms
- Open grazing model farms were more efficient, while semi-zero grazing model farms were less efficient.

The model dairy farms implemented some innovative practices that are designed to promote productivity, efficiency, and sustainability. These practices are informed by the climate conditions, feed resources, and market dynamics. Some of the practices observed among the model farms in this study include:

i. *Feed optimization and precision feeding*: Most model farms utilize high-quality, locally grown forage (e.g., Super Napier grass and Boma Rhodes grass) supplemented with own produced silage and hay to ensure consistent, high-nutrition feed. Others practice Total Mixed Ration feeding, which involves mixing various feed ingredients into a nutritionally balanced meal for cows. The majority of model farms also integrate protein-rich legumes like desmodium or lucerne in pastures to enrich feed quality and provide natural nitrogen.

ii. *Improved breed selection and genetic enhancement:* Many model farms employ selective breeding programs to develop high-yielding and resilient dairy breeds suited to their environmental conditions. However, there is still limited use of embryo transfer which can substantially improve the genetic quality and accelerate the multiplication of superior cows.

iii. *Innovative waste management systems:* Most of the model farms used dung and other dairy farm wastes in biogas digesters to produce energy for domestic heating and cooking. The by-product, liquid slurry, is used as organic fertilizer for fodder crops, closing the nutrient loop.

iv. *Sustainable pasture management and crop integration:* Most model dairy farms make own silage to ensure feed supply year-round. For open or semi-zero grazing systems, farmers practise rotational grazing on established pastures to avoid overgrazing, which promotes higher feed quality.

v. *Advanced health and disease management:* Some model dairy farms have on-farm diagnostic kits for early disease detection (such as mastitis tests) and on-farm veterinary officers, and undertake regular vaccinations, deworming schedules, and tick control programs, all aimed at controlling outbreaks of animal diseases on the farm and ensuring that the animals remain healthy. Furthermore, some farmers provide probiotics and nutritional supplements to animals. A few model farms have also invested in automated milking systems and smart sensors to monitor cow activity, milk production, and even health indicators like rumination and body temperature, enabling precision management.

vi. *Marketing innovation:* Some model farms have milk chilling units and sell directly to processors.

vii. *Training and knowledge transfer hubs:* Many model farms double as training centres for educating local farmers on best practices through field days and practical demonstrations at a fee, which is an additional revenue stream for the dairy enterprise.

For break-even milk production levels, it is important to note that farms with higher total costs generally need a higher break-even milk yield. Zero-grazing model farms, which have the highest total cost on average, need a break-even milk yield of 16.7 litres per cow per day, whereas open-grazing typical farms, which have the lowest total cost, have the lowest break-even milk yield of 4.4 litres per cow per day.

Break-even milk yield as a proportion of average milk yield illustrates how close or far a farm is from covering its total costs of production. Farms with values closer to 100% are operating further from their break-even point and have a smaller buffer against losses if their production level decreases. The break-even production level for a zero-grazing model farm is at 91% of its actual average yield, indicating a much smaller buffer against losses for such farms. In contrast, open grazing farms, both in the typical and model categories, have lower percentages (i.e. 61% and 69%, respectively), allowing more flexibility as their operational costs are lower.

Table 29: Comparison of typical and model dairy farms performance and break-even milk production levels

Item	Typical farms			Model farms		
	Zero grazing	**Semi-zero grazing**	**Open grazing**	**Zero grazing**	**Semi-zero grazing**	**Open grazing**
Average herd size	4	8	8	13	10	18
Average number of lactating cows	2	3	3	5	3	7
Proportion of lactating cows to herd size (%)	50	38	38	38	30	39
Average milk production	6,712	6,333	5,955	27,634	12,270	19,950
Average yield (litres/cow/year)	3,692	2,533	2,165	5,527	4,231	2,850
Average daily yield (litres/cow/day)	12.3	8.4	7.2	18.4	14.1	9.5
Average price per litre offered by main buyer (KES)	48.2	45.4	37	48.7	43.0	35.0
Main buyer	Dairy Coop.	Dairy Coop.	Dairy Coop.	Dairy Coop.	Dairy Coop.	Dairy Coop.
Average costs and margins per litre						
Value from milk (sold/consumed/calf)	49.3	45.7	38.4	49.4	52	39.2
Total variable costs (TVC)	23.8	15.1	8.5	26.6	17.1	2.5
Gross margin (revenue - TVC)	25.5	30.6	29.9	22.8	34.9	36.7
Total costs (TC)	39.5	37.3	24.5	44.1	39.3	24.2
Milk profits (revenue - TC)	9.8	8.4	13.9	5.2	12.7	15
Whole enterprise profit	14.8	11.6	20.1	12.8	15.3	29.4
Gross margin/TVC ratio	1.2	2.9	4.3	1.1	2	14.7
Gross margin rate (%)	50.5	67.4	78	45.4	67.1	93.6
Break-even yield analysis						
Break-even yield per cow	**9.2**	**5.8**	**4.4**	**16.7**	**12.5**	**6.6**
Break-even yield as a proportion of average yield (%)	75	69	61	91	88	69

3.3 Service delivery in the dairy sector

3.3.1 Livestock Extension Services

Extension services are crucial in improving livestock productivity through providing farmers with information that will help to make use of available resources at their disposal. Generally, extension service providers offer technical advice on livestock production, and services to support production such as market linkages, and linking farmers to other stakeholders. Additionally, they offer a range of information on production and available technologies to dairy farmers.

In all the counties visited, services were provided by various entities, including farmer cooperative societies, private sector companies, government programs (e.g., Agriculture Sector Development Support Programme (ASDSP), Small-Scale Irrigation and Value Addition Project (SIVAP), Kenya Climate Smart Agriculture Project (KCSAP); development partners (e.g., USAID, SNV); NGOs (e.g., Heifer International, Agricultural Finance Initiative (Agrifi), and dairy processors (e.g., KCC, Brookside). These organisations train and support farmers in areas like fodder production, animal breeding, husbandry and health, record keeping, sanitation, milk handling, housing, calf rearing, feeding and disease control.

Farmer access to extension services varied across counties, with private extension providers being the most preferred due to their availability and efficiency. These service providers mostly offer extension services to farmers as they provide them with inputs and services such as veterinary and artificial insemination services. Access to extension services from the county governments has decreased over the past five years due to budgetary constraints, leading to understaffed departments and limited farmer outreach.

Channels used to offer training included demonstration farms, field days, agricultural shows, exhibitions, radios, TVs, lead farmers, exchange visits and group training. Co-operatives employ extension officers, who train and offer services to farmers and are responsible for testing milk for density. Digicow Africa Ltd uses mobile-based technologies (Digicow app) to deliver extension services to farmers.

To improve extension services, various stakeholders suggested the following:

- County governments should hire more staff in the livestock department to reach more farmers
- Promote a pluralistic extension service delivery system where both public and private service providers are active allowing farmers to pay for service services they receive.
- County governments and co-operatives should increase budget allocation for extension services and facilitate field staff adequately to enable them deliver services efficiently. Facilitation should include funds for transport, fuel, and demonstration materials.

- County governments should improve the quality and timeliness of extension services in delivering information about technologies such as artificial insemination
- There should be enhanced collaboration between the government, private sector, and NGOs to ensure comprehensive and coordinated support to farmers
- Policy awareness: trainings by various stakeholders should incorporate sessions to create awareness on policies governing dairy production and their impact on dairy farm operations
- There should be improvement in transport and communication infrastructure to facilitate movement and communication of farmers and extension service providers

These improvements will ensure comprehensive and efficient support to dairy farmers, which could lead to enhanced productivity in the dairy sector.

3.3.2 Health management and breeding services

3.3.2.1 Livestock health services

Farmers recognized the importance of basic livestock health services such as deworming, vaccination, and parasite control. However, several constraints hinder the consistent implementation of these practices, which include limited veterinary services since there are not enough veterinary officers and funds allocated to meet the demand. High cost of health services is a significant barrier for many small-scale farmers, leading to inconsistent use of practices such as where some farmers deliberately skip or avoid essential services such as vaccination and tick control. To address these challenges, there is need to expand access to veterinary services and strengthen farmer training on best practices in animal health, breeding, and husbandry. This information will support consistent implementation of vital health services while boosting productivity and profitability. Implementing measures to control disease outbreaks is crucial to protecting animals and sustaining profitability. Effective management strategies, such as national vaccination programs, early warning systems, and strict quarantine controls for imported livestock, can significantly reduce the impact of livestock diseases.

3.3.2.2 Breeding services

There are several available types of AI, which include local semen, imported semen, sexed semen and embryo transplant. Over 80% of the farmers across all the counties use AI services to improve their cattle breeds, with a preference for local semen due to its availability and lower cost. Imported and sexed semen were popular among the model farmers while there was still limited use of embryo transfer. The most common breeds are crosses of Friesian, followed by Ayrshires, and Jersey. The sources of breeding services include the county government, dairy co-operatives and private practitioners. The latter was the most common source of AI. Though AI from private practitioners is expensive, farmers viewed them as a key source since the service providers are easily accessible and available.

Over the last five years, the cost of AI services has increased, making high quality breeding services more expensive. Despite subsidies from county governments and cooperatives, AI services provided by the county government are inefficient, with high repeat rates. The interviewed farmers rated the success rate of AI at around 50%. Farmers attribute AI failures to service providers, but the key informants such as county officials stated that proper timing of the cow's heat cycle and good dairy cow management are crucial for improving success rates.

To improve livestock health and breeding outcomes, there is a need to enhance veterinary/AI service access, provide better training to both farmers and AI technicians, and ensure more efficient and affordable AI services. This will help farmers achieve better productivity and profitability in dairy farming.

3.3.3 Feeds and Feeding

3.3.3.1 Quality of feeds

Feed quality was a major challenge in all the counties. Farmers reported that the quality of feeds supplied is of average quality and varies significantly from batch to batch, indicating lack of consistent quality control by feed manufacturing companies. Farmers reported that new companies entering the market often produce high quality feed initially, usually within three months to attract farmers. However, the quality declines afterwards.

Various feed companies supply feed to dairy farmers, and they differ across counties. The most common companies were Unga Limited, Pembe Limited, Joy Millers, and Pioneer Feeds. Farmers reported that the key indicators for good high-quality feeds were increased milk production, healthy appearance of the cows, provision of nutrition information on the package, and feeds' appearance, smell and colour.

There was little/no intervention from the county governments and other stakeholders to ensure feed quality except in Kiambu County, where Githunguri Dairy Cooperative conducts random sampling and analysis of feeds. Hence, in most cases, farmers use trial and error to assess the feed quality; they continue purchasing a particular feed if it associated with higher milk yield and promotes cow health.

The inconsistency in feed quality poses a significant challenge for dairy farmers, affecting both milk production and animal health. There is a need for stricter quality control measures from feed manufacturers, County and National governments. In particular, the governments must take a more active role in monitoring the feed manufacturers to ensure feeds are of high quality.

3.3.3.2 Feed formulation and feed preservation

Farmers across the counties have received training through farmer groups on feed formulation and preservation via county government initiatives and projects such as ASDSP, KCSAP and National Agricultural and Rural Inclusive Growth Project (NARIGP). Despite this, only a small percentage of farmers are actively practising feed formulation. Key informants and FGD

participants reported that only 2% of farmers were practising feed formulation in Bomet, 10% in Machakos and Trans Nzoia, with Kiambu reporting the highest adoption rate (80%). Farmers in the zero grazing production system reported practising feed preservation primarily by making silage and hay, and preservation of maize stover and bean residues. In open grazing and semi-zero systems, farmers rotate animals in paddocks to ensure the pasture grass regrows. Model farmers mentioned purchasing hay and silage at lower prices during the harvest season for later use.

The adoption rate of feed preservation remains low due to various resource-related challenges including lack of technical skills and knowledge (e.g. proper ways for feed preservation to avoid rotting and aflatoxin contamination during silage making); high cost of feed components; unavailability of good quality components (raw materials); lack of information on benefits of formulated feeds; lack of finances; lack of infrastructure (equipment required e.g. feed mixing mills); competition for land between food crops and animal feed crop production. Addressing these barriers could preserve the quality, efficacy, and performance of feeds, leading to higher milk productivity.

3.3.3.3 Feeding regime

In dairy production, a well-planned feeding regime is critical to achieving high milk yields, ensuring cow health, and maintaining farm profitability. A feeding regime includes the types of feed provided, their nutrient balance, and the timing and method of feeding. An effective feeding regime for dairy cattle should include forages, concentrates, protein supplements, mineral salts and vitamins and water, which should be provided through the recommended feeding frequency and timing, such as availing dairy cows with fresh, clean water ad libitum.

In counties where zero grazing and semi-zero grazing are practised, farmers reported feeding their cows at least twice a day, typically in the morning and in the afternoon. Additionally, they indicated that they normally feed their animals with dry matter, though not in sufficient daily quantities. In addition, cows have access to drinking water throughout the day. However, in the open grazing system, watering is done in the afternoon though the farmers revealed that they were aware of the recommended watering practice.

3.3.4 Labour in dairy production

Adoption of labour-saving technologies remains minimal in all the production systems. The most widely used technology is the chaff cutter especially in the zero grazing and semi-zero grazing systems. Some of the model farmers use milking machines, water tanks, hay balers, motorized transport, feed choppers, feed preservation and paddocking systems. Many farmers in some counties like Migori rely heavily on manual labour which limits productivity and increases the workload for farmers.

The primary barriers to the adoption of labour-saving technologies are the high cost of equipment and a lack of awareness of their benefits. Farmers suggested that facilitating access to affordable loans or cooperative buying schemes could enable them to invest in necessary

equipment. Further, stakeholders emphasized the need for training programs and demonstrations to raise awareness of the benefits of labour-saving technologies. Most labour saving technologies are driven by electric power and there is a need to develop others that are energy-use efficient, and that use solar power. Also, technologies should be designed with ergonomic considerations that make them easier for women to handle such as lightweight machinery.

3.3.5 Financial services

Most farmers receive inputs on credit from cooperatives through the check-off system. To improve access to finance and reduce barriers to accessing credit among farmers, some cooperatives such as Mukurwe-ini and Lelan have set up SACCOs. In addition, financial institutions such as the Equity Bank offer training on financial literacy and provide loans to farmers.

3.4 Challenges in dairy production

The major challenges affecting dairy production are high cost of fodder and commercial feeds especially for the zero-grazing system; insufficient access to quality breeds of dairy cattle and high cost of breeding including repeat breeding; and poor-quality animal feeds in the market. Farmers depend on purchased fodder and commercial feeds where fodder is not enough, which makes dairy farming costly. Weather related factors such as droughts and erratic rainfall exacerbate the feed problem, resulting in fodder shortages. Inconsistent availability and high cost of fodder and feeds imply that farmers do not always feed their animals a high-quality balanced diet, leading to low milk yields. It is recommended that farmers adopt new technologies, drought tolerant fodder varieties and effective pasture management. Variation in quality of feeds negatively impacts on animal health and milk production. There are instances when companies supply good quality feeds when introducing feeds to the markets but quality declines with time. Additionally, feed labels that describe the contents of the package differ from what is packaged. Dairy farms who rely on electric/fuel powered machines for milking and feeding may incur additional energy costs due to price volatility adding risks to dairy operations. Solar energy can drastically reduce cost of energy in the long term.

Other challenges include:

- Fluctuating milk prices that negatively affect farmer incomes, creating uncertainty in their operations
- Lack of transparency on the spread between the payout price and what the farmers receive; farmers' view is that they are underpaid by the cooperatives
- High cost of zero-grazing units and other necessary infrastructure required to boost milk productivity
- Weak policy enforcement---poor monitoring and enforcement of feeds standards result in the sale of substandard feeds

- Non-compliance with health regulations whereby farmers disregard important practices, such as observing withdrawal periods after use of antibiotics and using clean water for milking, which are critical for safety of milk
- Lack of testing for contaminants by cooperatives due to lack of the necessary equipment to detect aflatoxins and antibiotic residues, which have been found in nearly all counties, posing significant risk to milk quality and human health
- Unsafe handling practices like farmers using plastic containers for milking and transport, heightening contamination risks
- Increase in diseases and milk contamination during the rainy seasons, affecting the quality and quantity of milk
- Lack of access to quality and timely veterinary services for livestock leading to low milk yield or loss of animals
- Failure to keep records, that would otherwise enable farmers to track revenues and expenses, and make informed decisions with a view to reducing costs
- Practice of collecting milk once a day by cooperatives and other buyers leads farmers to store mid-morning and evening milk without refrigeration, and sell it the subsequent morning, comprising milk quality
- Shortage of chilling equipment at the co-operative level
- Poor roads and transport networks
- Limited access to quality extension services affecting the ability of farmers to receive timely and effective support
- Poor organisation of farmers leading to weak bargaining power when it comes to milk prices
- Inadequate knowledge of the utilization of manure waste for other valuable purposes such as the generation of biogas and the commercialization of the sale of manure in some regions

3.5 Milk pricing at farmgate

3.5.1 Computing guaranteed minimum producer price of milk

The ideal profit margin for a farm enterprise like dairy farming in Kenya can depend on several factors, such as market conditions, the scale of the operation, access to farm support programs such as subsidies, and production efficiency. For this study, the key considerations to determine a reasonable profit margin were:

a) *Cost of production*: Efficient producers with lower costs per litre can afford a lower profit margin, while those with higher costs might need a higher margin to remain profitable. For this study, we consider typical farms. The selection of typical farms incorporated the scale and systems of production as well as commercial orientation. This allows the cost of production presented to have a broader and unbiased representation of dairy farmers in the country.

b) *Dairy sector challenges in Kenya*: The sector is faced with high feed costs due to reliance on imports of raw materials, price volatility, limited access to cold storage and poor transportation and road network.

c) *Risk management*: A higher margin can act as a buffer for unforeseen challenges such as droughts, disease outbreaks, or market disruptions, which have been common phenomena in Kenya in the recent past.

d) *Government policies*: The key policy targets that the government has set for the industry and policy support provided. For example, the government targets to double milk production in five years. Hence, the price should incentivise farmers to increase production.

e) *Sustainability*: Farmers need to invest in infrastructure, equipment, and herd improvement, requiring a margin that allows for reinvestment.

In many developed dairy markets, the typical profit margin for dairy farming ranges from 10 to 20%. However, in more challenging environments, such as in Kenya where operational costs may be higher, a profit margin of 15-25% may be more suitable for small to medium-scale dairy farms especially those with moderate operational costs and who face market fluctuations. Further, a profit margin ranging from 20 to 30% is recommended for farms operating in much more challenging environments. These margins allow for sustainability, reinvestment, and profitability, while providing a buffer against Kenya's specific risks such input costs and market price volatility.

The KDB through the draft "The Dairy Industry (Pricing of Dairy Produce) Regulations, 2020" proposed a Minimum Farmgate price formula as shown below:

$$\boldsymbol{Fgp = (Cp + Cp(Pm) + T + C + Qv - Tx)0.95 \ldots\ldots\ldots\ldots\ldots\ldots (1)}$$

where $\boldsymbol{Cp}$ is cost of production, $\boldsymbol{Pm}$ is profit margin rate, $\boldsymbol{T}$ is transport cost, $\boldsymbol{C}$ is chilling cost, $\boldsymbol{Qv}$ is premium paid for quality and $\boldsymbol{Tx}$ is statutory deduction.

The proposed formula fails to account for realities that characterise the environment within which the dairy sector operates, including the following:

i. Market dynamics: Fixing transport and chilling costs and quality premiums in the formula is problematic because these costs are variable and impacted by factors beyond the Board's control. For example, fluctuating fuel costs directly influence transport and

chilling costs. A market-driven cost of transportation is more predictable and consistent and allows stakeholders to address the issue with relevant institutions, e.g. road agencies or county governments if this presents a challenge in accessing markets.

ii. Enforcement challenge due to informal markets: A large proportion of milk in Kenya is traded through informal channels, making it difficult to enforce the formula across the board. This informal market significantly influences local dairy pricing dynamics and limits the formula's effectiveness in regulating prices.

iii. Management fees: The 5% management fee in the formula appears high compared to sectors like tea, where similar fees were reduced after farmer protests. The Board needs to benchmark with other sectors and jurisdictions to come up with the rate for management fees.

iv. Differing incentives across stakeholders: The formula's structure may inadvertently push farmers facing high transport costs toward informal markets, where transport fees are not part of the pricing model.

v. Regulatory overlap: Dairy cooperatives are not regulated by the Board but by the Ministry in charge of Cooperative Development. Stronger coordination is needed in undertaking regulatory oversight, such as the efficient management of cooperatives.

A more straightforward formula considers only a target profit margin based on production costs and government pricing policies:

$$\boldsymbol{Fgp = Cp + Cp(Pm)} \quad \textbf{(2)}$$

Using the above formula (2) and the case for zero grazing typical farms where the total cost of producing a litre of milk was KES 39.5 (Table 9), a range of minimum farm gate prices at different profit margins is presented in Table 30. The results show a set of prices of KES 45 at a 15% margin, KES 47 at 20%, and KES 51 at 30%. It is important to note that the government's announced minimum price of KES 50/litres would confer a margin of 28%.

This pricing approach and formula allow market dynamics to create the relevant pricing signals in a sector where seasonality in supply leads to significant price fluctuations.

Table 30: Calculation of minimum producer price

Total cost (TC)	*Profit margin rate (Pm) (%)*	*Profit margin (TC*Pm) (KES)*	*Minimum farm gate price*
39.5	15	6	45
39.5	20	8	47
39.5	25	10	49
39.5	30	12	51

3.5.2 Pros and cons of a guaranteed minimum producer price of milk

A guaranteed minimum price (GMP), or price floor, for an agricultural product, is set by the government and typically established above the market equilibrium price to prevent excessively low prices for the product. The rationale for GMP includes protecting farmers' incomes, promoting production, and addressing market failures resulting from monopoly power. Despite its rationale and benefits, such as ensuring price stability and income security for farmers, establishing a guaranteed minimum producer price for milk can have detrimental effects.

First, if the price is set excessively high, Kenya's dairy products may be less competitive in the international market, undermining the government's strategy to boost dairy exports. Secondly, farmers may have diminished motivation to implement more efficient practices, invest in technology, or engage in innovation. Thirdly, and related to the second point, farmers may prioritize quantity over quality, resulting in products of inferior quality that do not meet consumer expectations or standards in export markets. Fourth, consumer prices for dairy products in the domestic market may increase.

The government should thoughtfully formulate and execute the policy on guaranteed minimum price for milk in a way that mitigates potential issues, considering the cost of milk production, local market conditions, and the possible effects on international trade. It is imperative to note that the GMP cannot be a stand-alone intervention. It needs to be supported by a Price Stabilization Fund. The government has planned to establish a KES 3 billion stabilization fund to be managed through the New KCC, but the following questions persist:

1. Does the government have the financial capacity to maintain/sustain a guaranteed minimum price? Will the government be able to consistently maintain/sustain a guaranteed minimum price?

2. Are the complementary interventions that will ensure that the GMP policy works in place? For example, has the processing capacity of the new KCC to convert excess milk into a strategic food reserve in the form of dry milk powder been increased?

3. Will dairy processors other than the New KCC have the incentive to increase the price of milk to match the GMP, particularly during a milk supply glut? Will a government directive to increase prices paid to milk producers be sufficient?

4. Are the logistics for implementing the GMP in place? How will farmers who sell milk to processors other than the New KCC directly or through cooperatives be brought on board?

5. Is a one-size-fits-all GMP feasible, given that this study shows variations in prices, geographies, practices and costs across production systems?

4 Conclusion and Recommendations

4.1 Conclusion

This study assessed the cost of and returns to milk production in 25 dairy-producing counties using a combination of the typical farm approach, key informant interviews and a survey of model dairy farms. In each county, data for a typical farm were collected through a focus group discussion and interviews conducted with one to two model farms, for a total of 25 typical and 30 model dairy farms. The study considered three dairy production systems (zero, semi-zero and open grazing).

For typical farms, milk yield was highest in zero grazing and lowest in the open grazing system. Gross revenue per litre of milk was highest in zero grazing and lowest in open grazing system. While most of the milk was sold through cooperatives, other milk buyers included milk vendors and individual consumers. Cooperatives generally offered lower prices than other buyers, except in Meru and Tharaka Nithi, because of the linkage of the cooperatives to the local processor – Meru Dairy Cooperative Union. Differences in milk prices offered by different buyers could account for the variations in gross revenue per litre of milk across the production systems and counties. In addition, differences in milk pricing across the counties could result from variations in bargaining power, cooperative society strengths and efficiency, market access and infrastructure.

Production costs varied by system and scale of production, and they were highest in the zero-grazing and lowest in the open-grazing system. This is because the latter used less purchased feed, which was a significant driver of costs in the zero and semi-zero grazing systems. Consequently, farms in the open grazing system had the highest gross margin, milk profits and whole enterprise profit. While semi-zero grazers had a higher gross margin than the zero grazers, the latter had higher milk and whole enterprise profit. Overall, the positive gross margins and profits indicate that dairy farming is profitable across the three production systems. In terms of efficiency, which is measured by the gross margin to TVC ratio, open grazers were most efficient and zero grazers least efficient.

Feed concentrates, hired labour, purchased fodder/pasture and health management and breeding accounted for the most significant cost shares, with their relative importance varying across the production systems. For zero grazers, feed concentrates followed by purchased fodder/pasture had the largest share in TVC, while for semi-zero grazers, the key drivers of costs were feed concentrates, hired labour and health management and breeding costs. Health management and breeding costs, mineral salts and feed concentrates, in that order, were the key cost components in the open grazing system. Overall, feed and labour were the most significant drivers of the cost of milk production.

There were variations in the production costs and margins between model and typical farms. Relative to their counterparts in the typical farm category, zero and open-grazing model farms had more lactating cows, while semi-zero grazers had the same number. Milk yield was higher for model farms in all the production systems. The TVC were higher for zero and semi-zero

grazing model farms but lower for model open grazers. Gross margin, milk profit and whole enterprise profit were higher for model semi-zero and open grazers but lower for model zero grazers. Regarding efficiency, model open grazers performed better, while semi-zero grazers were less efficient. Model zero grazers had the same gross margin to TVC ratio as their typical farm counterparts.

Farmers received extension services from various providers, but access to these services varied across counties. Extension service delivery by county governments has decreased over the past five years due to inadequate funding and staffing. Private input sellers and service providers, cooperatives, agricultural development projects and programs and digital technology innovations have become essential sources of extension services.

Farmers recognized the importance of livestock health management, but the high cost of health services, which were provided mainly by private practitioners, was a significant challenge to them. Over 80 percent of farmers used artificial insemination services provided mainly by county governments, cooperatives, and private practitioners. The latter were the most used but also the most expensive. Farmers decried the low success rate of artificial insemination, which was attributed to low-quality semen, improper timing of the cow's heat cycle, and poor dairy cow management.

Poor feed quality, especially for commercial feeds, was reported to be a significant challenge, and there was little to no intervention to monitor the feed quality in the market. For farmers, the level of milk production, the physical appearance of the cow after feeding, and information on the feed packaging were the key indicators they used to judge feed quality. The inconsistency in feed quality poses a significant challenge and may affect both milk production and animal health. Farmers across the counties have received training through farmer groups on feed formulation and preservation, but few of them have adopted these practices, citing cost as the major limitation. In addition, most farmers were not observing optimal dairy animal feeding regimes.

There was heavy dependence on manual labour in dairy production, mainly because of a lack of awareness of available labour-saving technologies and their associated high costs. Chaff cutters were the most utilized labour-saving equipment, particularly in zero—and semi-zero grazing systems.

4.2 Recommendations

Although zero grazing is encouraged due to declining land sizes, the study findings show that the system has the highest costs and lowest returns. Important areas require attention to improve dairy farmers' returns.

For government:

i. Reduce the cost of feed by lowering taxes on feeds, raw materials, and equipment for feed formulation and manufacturing

ii. Enhance monitoring and enforcement of the quality of feeds and raw materials in the market. At present, there are structural weaknesses in the feed industry that allow small millers to avoid regulatory oversight. Strengthening the industry association, enhancing the training of farmers to demand and identify high-quality feeds, and greater enforcement of feed quality standards can address this challenge. This could be done by establishing feed testing laboratories in different regions, perhaps through the County Economic Blocs, for convenience and accessibility of the service by the farmers

iii. Promote adoption of cattle breeds that are more adaptable to local conditions and have better feed conversion efficiency in the different agroecological zones. This can be done by enhancing AI services through collaboration between the government and private service providers and educating farmers about alternative breeds such as the Ayrshire that may be better than the commonly kept Friesian breed.

iv. To increase the profitability of dairy production through cooperatives, the government could establish regulations and policies that promote market access, build cooperative capacity, enhance management efficiency, and create a more favourable economic climate for dairy producers. By maximizing the potential of cooperatives as marketing outlets, dairy farmers can benefit from better prices, reduced marketing costs, and access to valuable resources and training.

v. To address the high labour costs in dairy farming, particularly in open grazing farms where labour is often needed for herding, feeding, and general livestock care, extension advice could focus on improving labour efficiency and introducing labour-saving technologies.

vi. To maximize the cost-reducing benefits of on-farm fodder production and improve the quality of farm-grown and conserved feeds like silage, policy interventions can concentrate on a number of areas, including encouraging farm self-sufficiency in feed, providing financial incentives, fostering quality standards, and offering technical training and resources.

For aggregators and processors:

i. Reduce the cost of feeds by formulating feeds at the cooperative/processor level so that farmers can benefit from economies of scale. Also, the cooperative/processor can get into a contract with a feed manufacturer that can provide feeds, making it easier to monitor feed quality.

ii. Enhance transparency in milk pricing and timeliness of payment to farmers

iii. Dairy cooperatives should strengthen governance and management by hiring qualified staff and managers and sensitizing cooperative leaders and members

iv. Provide information and training to farmers on dairy herd management for practices such as culling, heat detection, nutrition and health management. For example, dairy

cows should be culled after 4 to 6 lactations (or about 6 to 8 years of age) when milk production declines. These management practices may require some capital input but will result in improved milk yield and farmer return

For farmers:

To reduce the cost of production, dairy farmers ought to:

i. Adopt high-quality fodder production, utilization, and on-farm feed preservation.

ii. Adopt best dairy herd management practices using knowledge received from trainings offered by different stakeholders

iii. To address the high labour costs in dairy farming, particularly on open grazing farms where labour is often needed for herding, feeding, and general livestock care, farmers should adopt labour-saving technologies

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Appendix

Table A1: Costs and margins per litre of milk production for typical farms, by production system

	Zero grazing	Semi-zero grazing	Open grazing	Overall
Gross revenue from milk (sold +consumed)	**49.3**	**45.7**	**38.4**	**46.1**
Purchased fodder/pasture	5.1	0.3	0.2	2.4
Feed concentrates	11.6	5.7	1.9	7.7
Mineral salts	1.2	1.4	2.1	1.4
Water (purchased)	0.4	0.1	0.1	0.2
Health and breeding costs	1.8	3.0	3.2	2.5
Milking jelly	0.2	0.3	0.2	0.2
Hired labour	2.2	3.5	0.0	2.3
Repairs on fixed assets	0.6	0.7	0.7	0.7
Other costs (e.g. electricity, fuel)	0.7	0.2	0.0	0.4
Total variable costs (TVC)	**23.8**	**15.1**	**8.5**	**17.9**
Gross margin (revenue - TVC)	**25.5**	**30.6**	**29.9**	**28.2**
Depreciation (fixed assets)				
Own fodder/pasture	5.0	11.2	6.2	7.7
Family labour	10.7	11.1	9.8	10.7
Total costs (TC = TVC + depreciation + own labour + own fodder)	**39.5**	**37.3**	**24.5**	**36.2**
Milk profits (revenue - TC)	**9.8**	**8.4**	**13.9**	**9.9**
Other revenue (sale of livestock, manure, bull services)	5.0	3.2	6.2	4.5
Whole enterprise profit (Milk profits + Other revenue)	**14.8**	**11.6**	**20.1**	**14.4**
Gross margin/TVC ratio	1.2	2.9	4.3	2.4
Gross margin rate (%)	50.5	67.4	78.0	61.7

Table A2: Costs and margins (KES) per litre of milk production for zero grazing typical farms

Production system	**County**											
County	**Embu**	**Kajiado**	**Kericho**	**Kiambu**	**Kirinyaga**	**Machakos**	**Meru**	**Murang'a**	**Nyeri**	**Taita Taveta**	**Tharaka Nithi**	**Average (SS)**
Gross revenue from milk (sold +consumed)	**46.0**	**64.0**	**45.6**	**48.0**	**50.0**	**49.7**	**54.7**	**43.9**	**41.5**	**43.7**	**55.0**	**49.3**
Purchased fodder/pasture	6.2	2.7	0.0	3.4	2.2	9.4	0.0	15.3	4.1	9.3	3.0	5.1
Feed concentrates	15.8	7.3	12.7	22.0	12.8	0.0	14.0	9.7	12.2	10.4	11.1	11.6
Mineral salts	0.9	4.5	2.0	1.1	0.4	0.0	1.0	1.6	0.5	0.8	0.9	1.2
Water (purchased)	0.2	0.5	0.0	1.1	0.0	1.2	0.3	0.2	0.3	0.3	0.3	0.4
Health and breeding costs	2.0	1.2	1.1	1.3	1.6	1.5	2.4	0.8	0.7	5.0	2.8	1.8
Milking jelly	0.2	0.2	0.2	0.1	0.0	0.4	0.1	0.3	0.3	0.0	0.4	0.2
Hired labour	0.0	3.7	6.7	1.4	0.0	8.6	0.0	3.5	0.0	0.0	0.0	2.2
Repairs on fixed assets	0.9	0.2	1.0	0.2	0.0	1.2	0.3	0.2	0.3	0.5	1.5	0.6
Other costs (e.g. electricity, fuel)	0.7	0.0	0.9	2.3	0.0	0.6	0.3	0.8	0.8	0.0	0.9	0.7
Total variable costs (TVC)	**26.8**	**20.3**	**24.5**	**32.9**	**17.0**	**22.8**	**18.2**	**32.4**	**19.2**	**26.3**	**20.9**	**23.8**
Gross margin (revenue - TVC)	**19.2**	**43.7**	**21.1**	**15.1**	**33.0**	**26.9**	**36.5**	**11.5**	**22.2**	**17.5**	**34.1**	**25.5**
Depreciation (fixed assets)												
Own fodder/pasture	0.6	6.1	9.8	4.2	2.1	4.1	6.3	1.9	11.2	5.2	3.3	5.0
Family labour	21.1	11.3	0.0	5.7	17.0	9.3	6.3	0.0	14.3	18.6	14.5	10.7
Total costs (TC = TVC + depreciation + own labour + own fodder)	**48.4**	**37.7**	**34.3**	**42.9**	**36.2**	**36.2**	**30.7**	**34.3**	**44.8**	**50.0**	**38.8**	**39.5**
Milk profits (revenue - TC)	**-2.4**	**26.3**	**11.3**	**5.1**	**13.8**	**13.5**	**24.0**	**9.6**	**-3.3**	**-6.3**	**16.2**	**9.8**
Other revenue (sale of livestock, manure, bull services)	3.5	0.3	0.7	1.6	4.3	3.6	0.0	0.3	32.3	1.3	7.6	5.0
Whole enterprise profit	**1.1**	**26.6**	**12.0**	**6.7**	**18.1**	**17.1**	**24.0**	**9.9**	**29.0**	**-5.0**	**23.8**	**14.8**
Gross margin/TVC ratio	0.7	2.1	0.9	0.5	1.9	1.2	2.0	0.4	1.2	0.7	1.6	1.2
Gross margin rate (%)	41.7	68.2	46.2	31.4	66.0	54.1	66.7	26.2	53.6	39.9	61.9	50.5

Table A3: Costs and margins (KES) per litre of milk production for semi-zero grazing typical farms (small-scale)

Production system	**County**							
	Baringo	**Bungoma**	**Kakamega**	**Kisii**	**Migori**	**Nyandarua**	**Trans Nzoia**	**Average (SS)**
Gross revenue from milk (sold +consumed)	**47.1**	**34.8**	**75.0**	**50.0**	**50.0**	**44.4**	**41.1**	**48.9**
Purchased fodder/pasture	0.0	0.0	2.0	0.7	0.0	0.0	0.0	0.4
Feed concentrates	12.4	0.0	5.8	10.8	4.3	5.4	2.5	5.9
Mineral salts	0.3	0.0	1.2	5.1	0.9	0.4	0.7	1.2
Water (purchased)	0.1	0.0	0.0	0.0	0.0	0.4	0.2	0.1
Health and breeding costs	2.3	3.2	6.0	2.8	3.0	2.2	3.7	3.3
Milking jelly	0.2	0.4	0.6	0.2	0.1	0.2	0.4	0.3
Hired labour	0.0	0.0	0.0	11.3	14.0	0.0	0.0	3.6
Repairs on fixed assets	0.2	1.1	2.0	0.7	1.0	0.6	0.5	0.9
Other costs (e.g. electricity, fuel)	0.0	0.0	0.0	0.0	0.5	1.1	0.0	0.2
Total variable costs (TVC)	**15.5**	**4.7**	**17.5**	**31.5**	**23.7**	**10.4**	**7.9**	**15.9**
Gross margin (revenue - TVC)	**31.6**	**30.1**	**57.5**	**18.5**	**26.3**	**34.0**	**33.2**	**33.0**
Depreciation (fixed assets)								
Own fodder/pasture	13.1	16.4	6.9	9.5	10.2	22.3	13.4	13.1
Family labour	5.8	15.8	23.5	5.9	11.6	9.9	12.3	12.1
Total costs (TC = TVC + depreciation + own labour + own fodder)	**34.3**	**36.8**	**47.9**	**46.9**	**45.5**	**42.6**	**33.7**	**41.1**
Milk profits (revenue - TC)	**12.8**	**-2.0**	**27.1**	**3.1**	**4.5**	**1.8**	**7.4**	**7.8**
Other revenue (sale of livestock, manure, bull services)	5.4	0.0	7.6	1.9	2.9	0.0	2.7	2.9
Whole enterprise profit	**18.2**	**-2.0**	**34.8**	**5.0**	**7.4**	**1.8**	**10.1**	**10.8**
Gross margin/TVC ratio	2.0	6.5	3.3	0.6	1.1	3.3	4.2	3.0
Gross margin rate (%)	67.1	86.6	76.7	36.9	52.6	76.6	80.8	68.2

Table A4: Costs and margins (KES) per litre of milk production for semi-zero grazing typical farms (medium scale)

Production system	**County**			
	Bomet	**Nandi**	**Uasin Gishu**	**Average (MS)**
Gross revenue from milk (sold +consumed)	**38.7**	**38.0**	**37.9**	**38.2**
Purchased fodder/pasture	0.0	0.2	0.0	0.1
Feed concentrates	11.1	1.6	3.1	5.3
Mineral salts	2.0	0.9	2.5	1.8
Water (purchased)	0.0	0.0	0.0	0.0
Health and breeding costs	1.2	3.0	3.0	2.4
Milking jelly	0.1	0.2	0.3	0.2
Hired labour	6.1	0.0	3.1	3.1
Repairs on fixed assets	0.7	0.4	0.1	0.4
Other costs (e.g. electricity, fuel)	0.0	0.0	0.0	0.0
Total variable costs (TVC)	**21.3**	**6.3**	**12.1**	**13.2**
Gross margin (revenue - TVC)	**17.4**	**31.7**	**25.7**	**24.9**
Depreciation (fixed assets)				
Own fodder/pasture	8.6	11.4	0.0	6.6
Family labour	0.0	17.9	7.8	8.6
Total costs (TC = TVC + depreciation + own labour + own fodder)	**29.9**	**35.5**	**20.0**	**28.5**
Milk profits (revenue - TC)	**8.8**	**2.5**	**17.9**	**9.7**
Other revenue (sale of livestock, manure, bull services)	0.0	10.4	1.2	3.9
Whole enterprise profit	**8.8**	**12.9**	**19.1**	**13.6**
Gross margin/TVC ratio	0.8	5.0	2.1	2.7
Gross margin rate (%)	44.9	83.5	68.0	65.4

Table A5: Costs and margins (KES) per litre of milk production for open grazing typical farms (small scale)

County	**Nakuru**
Gross revenue from milk (sold +consumed)	**41.9**
Gross revenue for milk consumed	7.5
Gross revenue for milk given to calf	0.0
Purchased fodder/pasture	0.0
Feed concentrates	7.7
Mineral salts	1.9
Water (purchased)	0.0
Health and breeding costs	4.9
Milking jelly	0.3
Hired labour	0.0
Repairs on fixed assets	0.2
Other costs (e.g. electricity, fuel)	0.0
Total variable costs (TVC)	**15.0**
Gross margin (revenue - TVC)	**26.9**
Depreciation (fixed assets)	
Own fodder/pasture	2.6
Family labour	14.5
Total costs (TC = TVC + depreciation + own labour + own fodder)	**32.1**
Milk profits (revenue - TC)	**9.8**
Other revenue (sale of livestock, manure, bull services)	3.6

Whole enterprise profit	**13.4**
Gross margin/TVC ratio	1.8
Gross margin rate (%)	64.2

Table A6: Costs and margins (KES) per litre of milk production for open grazing farms typical (medium scale)

	County			
	Elgeyo Marakwet	**Narok**	**West Pokot**	**Average (MS)**
Gross revenue from milk (sold +consumed)	**45.2**	**32.9**	**33.6**	**37.2**
Purchased fodder/pasture	0.0	0.0	0.9	0.3
Feed concentrates	0.0	0.0	0.0	0.0
Mineral salts	4.4	2.0	0.0	2.1
Water (purchased)	0.0	0.0	0.3	0.1
Health and breeding costs	1.8	3.3	3.0	2.7
Milking jelly	0.1	0.3	0.2	0.2
Hired labour	0.0	0.0	0.0	0.0
Repairs on fixed assets	0.3	2.1	0.3	0.9
Other costs (e.g. electricity, fuel)	0.0	0.0	0.0	0.0
Total variable costs (TVC)	**6.5**	**7.7**	**4.8**	**6.3**
Gross margin (revenue - TVC)	**38.7**	**25.2**	**28.8**	**30.9**
Depreciation (fixed assets)				
Own fodder/pasture	8.6	4.4	9.3	7.4
Family labour	7.1	10.0	7.4	8.2
Total costs (TC = TVC + depreciation + own labour + own fodder)	**22.3**	**22.1**	**21.5**	**21.9**
Milk profits (revenue - TC)	**22.9**	**10.8**	**12.1**	**15.3**
Other revenue (sale of livestock, manure, bull services)	0.0	16.7	4.6	7.1
Whole enterprise profit	**22.9**	**27.4**	**16.8**	**22.4**
Gross margin/TVC ratio	5.9	3.3	6.0	5.1
Gross margin rate (%)	85.5	76.7	85.8	82.7

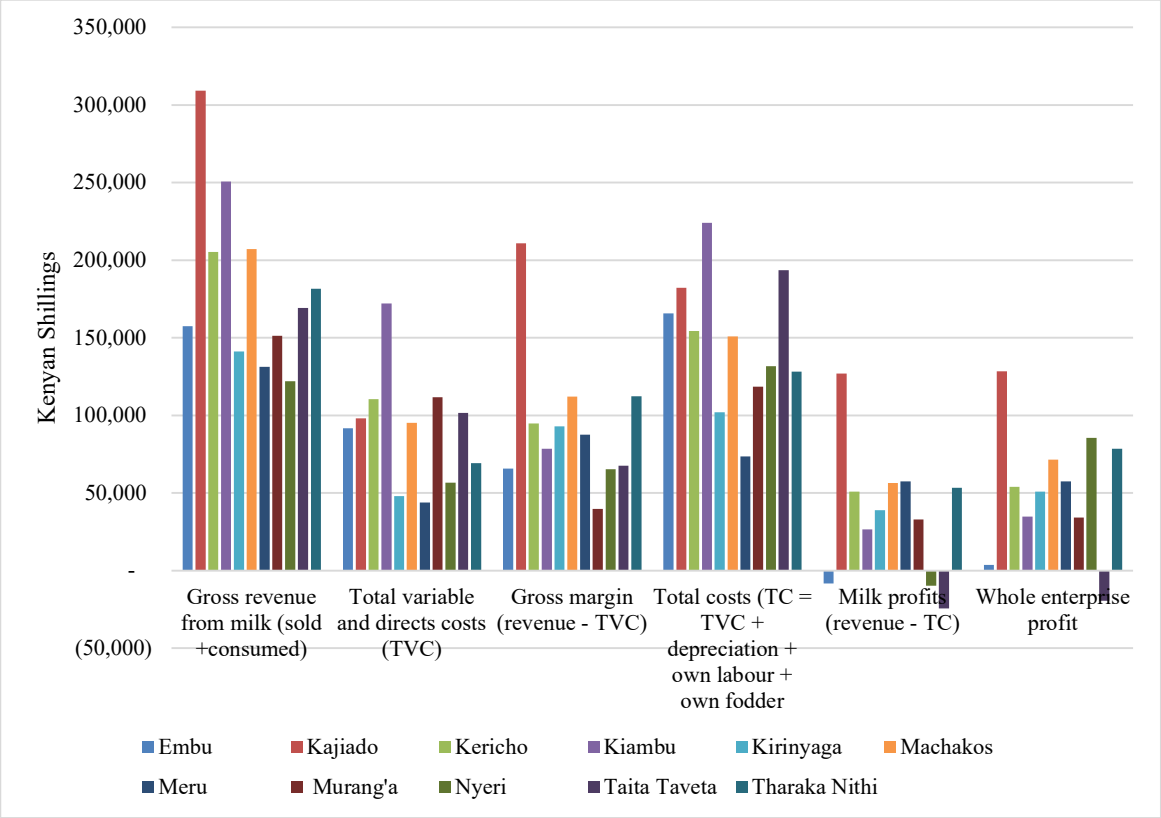

Figure A1: Costs and returns in KES per lactating cow per year for zero grazing typical farms (small scale)

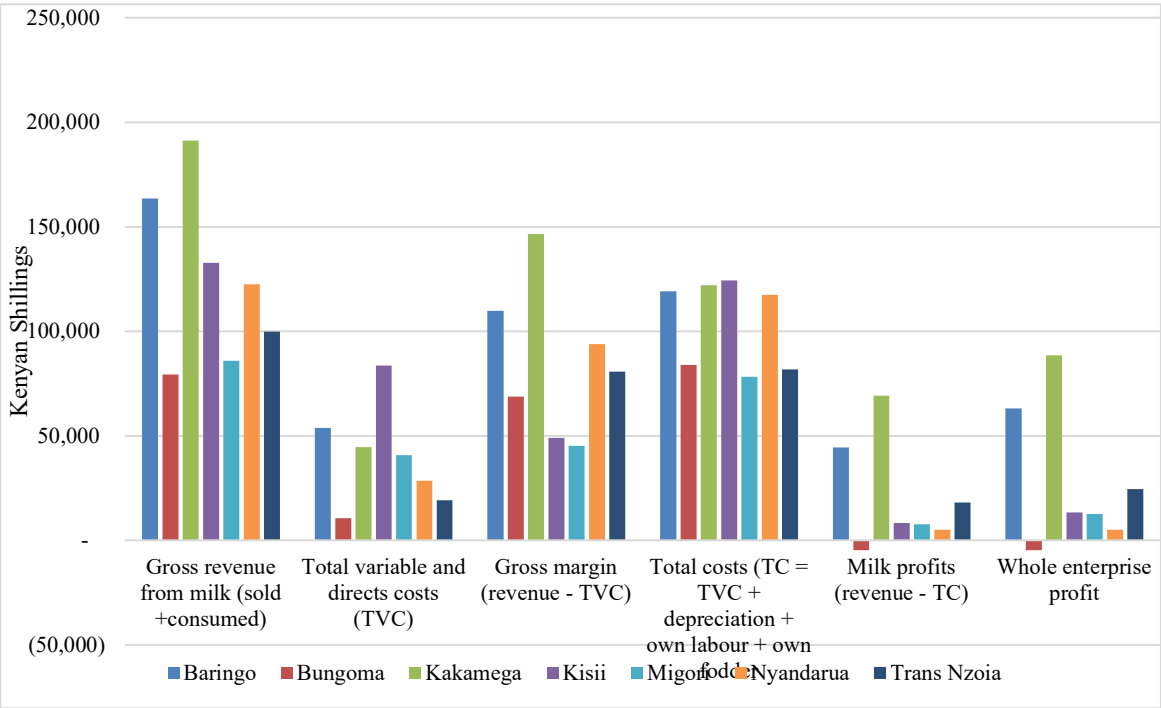

Figure A2: Costs and returns in KES per lactating cow per year for semi-zero grazing typical farms (small scale)

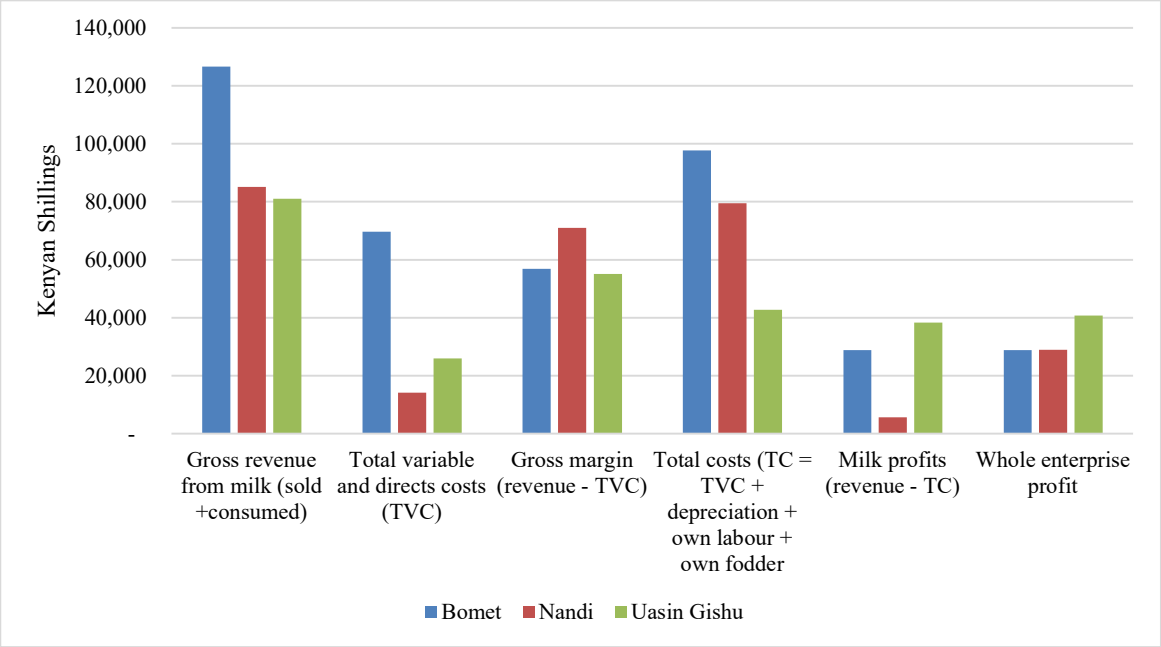

Figure A3: Costs and returns in KES per lactating cow per year for semi-zero grazing typical farms (medium scale)

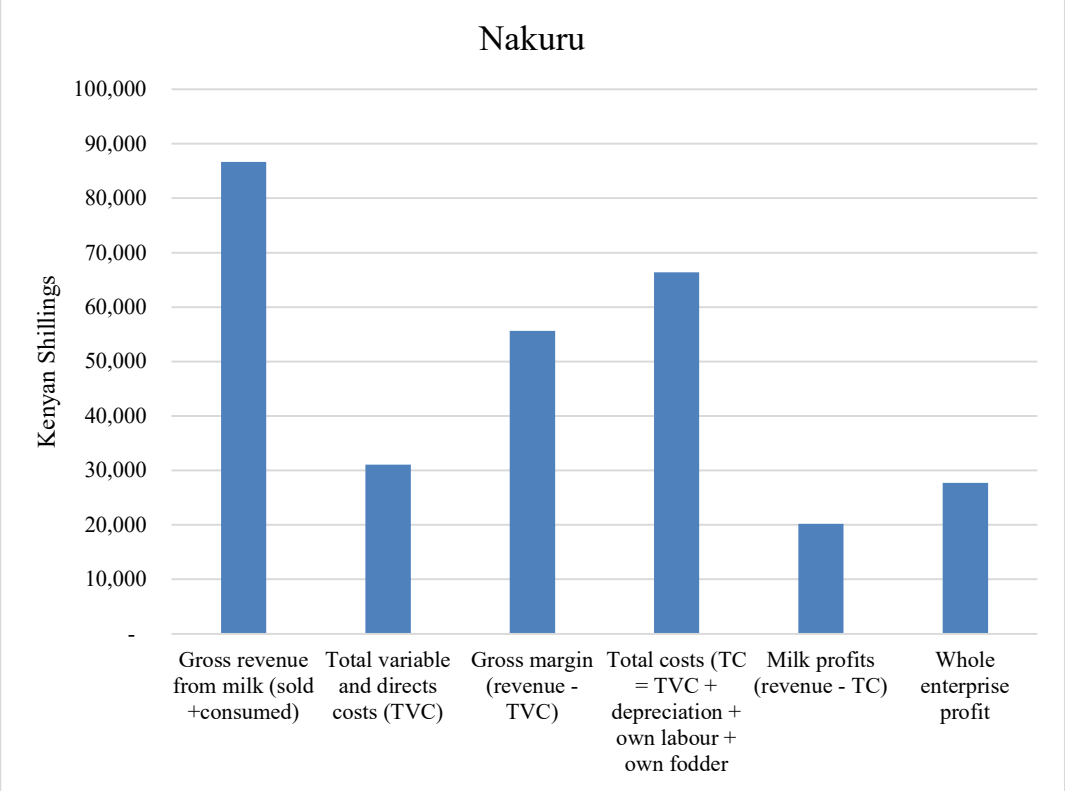

Figure A4: Costs and returns in KES per lactating cow per year for open grazing typical farms (medium scale)

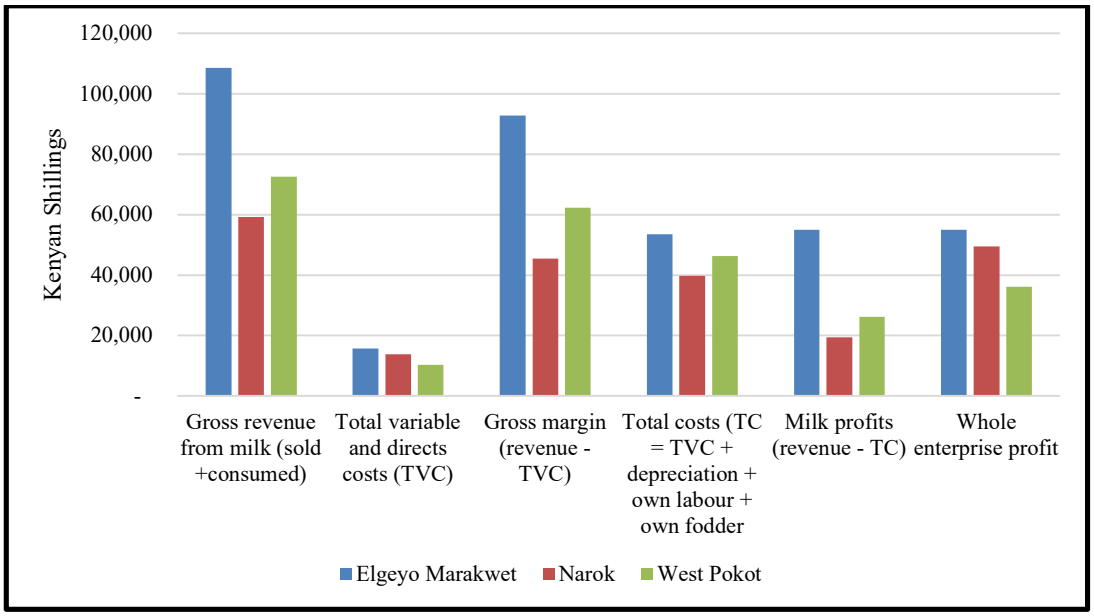

Figure A5: Costs and returns in KES per lactating cow per year for open grazing typical farms (medium scale)

Table A7: Average costs and margins per litre of milk production for model farms, by production system

	Zero grazing-1 (n=17)	**Semi-zero grazing (n=10)**	**Open grazing (n=1)**	**Zero grazing-2 (n=2)**
Gross revenue from milk (sold +consumed)	**49.4**	**52.0**	**39.2**	60.0
Purchased fodder/pasture	2.9	0.7	0.0	0.8
Feed concentrates	12.8	5.3	0.0	15.3
Mineral salts	1.9	1.7	0.2	1.7
Water (purchased)	0.3	0.1	0.0	0.03
Health and breeding costs	1.6	3.1	0.9	1.0
Milking jelly	0.2	0.2	0.1	0.2
Hired labour	5.9	5.3	0.0	9.5
Repairs on fixed assets	0.5	0.5	1.3	0.3
Other costs (e.g. electricity, fuel)	0.5	0.2	0.0	0.4
Total variable costs (TVC)	**26.6**	**17.1**	**2.5**	**29.5**
Gross margin (revenue - TVC)	**22.8**	**34.9**	**36.7**	**30.5**
Depreciation (fixed assets)	1.8	0.9		0.5
Own fodder/pasture	10.7	13.6	17.5	13.7
Family labour	5.0	7.7	4.2	0.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	**44.1**	**39.3**	**24.2**	**43.4**
Milk profits (revenue - TC)	**5.2**	**12.7**	**15.0**	**16.6**
Other revenue (sale of livestock, manure, bull services)	7.5	2.6	14.4	5.9
Whole enterprise profit	**12.8**	**15.3**	**29.4**	22.5
Gross margin/TVC ratio	1.1	2.0	14.7	1.0
Gross margin rate (%)	45.4	67.1	93.6	50.6

Table A8: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (Small scale)

Production system	**Zero Grazing**			
County	**Embu**	**Kajiado**	**Nakuru 2**	**Nyandarua**
Gross revenue from milk (sold +consumed)	**53.5**	**58.9**	**44.0**	**43.5**
Purchased fodder/pasture	0.0	0.0	0.0	13.3
Feed concentrates	8.0	3.2	8.8	17.1
Mineral salts	1.2	7.5	3.1	0.8
Water (purchased)	0.1	2.1	0.0	0.1
Health and breeding costs	2.0	0.6	1.0	1.1
Milking jelly	0.2	0.2	0.2	0.4
Hired labour	6.9	8.7	5.2	4.4
Repairs on fixed assets	0.6	0.0	1.3	0.6
Other costs (e.g. electricity, fuel)	0.6	0.4	0.0	0.3
Total variable costs (TVC)	**19.6**	**22.7**	**19.6**	**38.1**
Gross margin (revenue - TVC)	**33.9**	**36.2**	**24.4**	**5.4**
Depreciation (fixed assets)	0.3	1.0	1.3	0.8
Own fodder/pasture	9.9	8.0	7.7	2.9
Family labour	10.9	19.1	8.1	10.6
Total costs (TC = TVC + depreciation + own labour + own fodder)	**40.7**	**50.8**	**36.8**	**52.4**
Milk profits (revenue - TC)	**12.8**	**8.1**	**7.3**	**-8.9**
Other revenue (sale of livestock, manure, bull services)	2.3	12.3	0.0	0.0
Whole enterprise profit	**15.1**	**20.4**	**7.3**	**-8.9**
Gross margin/TVC ratio	1.7	1.6	1.2	0.1
Gross margin rate (%)	63.3	61.5	55.4	12.5

Table A9: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (Medium scale)

Production system	**Zero Grazing**												
County	**Baringo**	**Kericho**	**Kiambu**	**Kiriny aga**	**Machakos**	**Meru**	**Murang'a**	**Nandi**	**Nyeri-Kieni**	**Nyeri-Mukurweini**	**Taita Taveta**	**Trans Nzoia**	**Uasin Gishu**
Gross revenue from milk (sold +consumed)	**40.8**	**45.7**	**49.5**	**49.0**	**61.5**	**56.7**	**50.0**	**44.7**	**46.0**	**45.0**	**49.7**	**60.7**	**40.0**
Purchased fodder/pasture	0.0	0.8	1.1	15.6	0.0	0.0	10.3	0.0	1.0	6.6	0.7	0.4	0.4
Feed concentrates	6.2	11.4	23.1	16.5	22.5	12.7	13.9	9.5	19.1	11.2	17.8	5.0	11.2
Mineral salts	1.1	2.6	1.4	1.1	1.0	1.1	1.4	0.5	0.4	5.5	1.3	1.5	0.4
Water (purchased)	0.2	0.0	0.1	0.7	0.3	0.0	0.1	0.0	0.0	0.8	0.0	0.1	0.0
Health and breeding costs	0.8	2.0	1.3	2.1	0.7	1.9	2.5	2.3	1.2	3.1	2.1	2.4	0.9
Milking jelly	0.1	0.2	0.2	0.5	0.2	0.0	0.0	0.0	0.1	0.3	0.2	0.0	0.1
Hired labour	2.7	5.1	3.5	0.5	10.2	4.7	3.5	11.4	4.8	7.4	8.8	3.5	9.3
Repairs on fixed assets	0.0	0.2	0.8	0.1	0.3	1.2	0.6	0.4	0.2	0.2	0.6	0.3	0.2
Other costs (e.g. electricity, fuel)	0.5	0.4	0.1	0.6	1.3	0.7	1.2	0.0	1.0	1.2	0.0	0.1	0.0
Total variable costs (TVC)	**11.6**	**22.6**	**31.5**	**37.8**	**36.4**	**22.3**	**33.6**	**24.2**	**27.9**	**36.4**	**31.5**	**13.3**	**22.4**
Gross margin (revenue - TVC)	**29.2**	**23.1**	**17.9**	**11.2**	**25.1**	**34.4**	**16.4**	**20.5**	**18.1**	**8.6**	**18.2**	**47.4**	**17.6**
Depreciation (fixed assets)	1.3	0.3	0.2	0.8	7.3	3.5	2.0	5.6	1.6	0.6	1.6	1.5	0.6
Own fodder/pasture	21.4	9.3	3.0	2.1	23.2	14.5	4.0	14.2	12.2	3.5	11.1	22.3	12.6
Family labour	4.5	0.0	9.2	0.0	0.0	6.5	6.2	0.0	7.1	0.0	0.0	2.9	0.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	**38.8**	**32.2**	**44.0**	**40.7**	**66.9**	**46.8**	**45.7**	**44.0**	**48.8**	**40.6**	**44.2**	**40.1**	**35.6**
Milk profits (revenue - TC)	**1.9**	**13.5**	**5.5**	**8.3**	**-5.4**	**9.9**	**4.3**	**0.6**	**-2.8**	**4.4**	**5.5**	**20.6**	**4.4**
Other revenue (sale of livestock, manure, bull services)	7.3	6.3	15.2	16.4	0.0	28.9	10.0	5.2	0.0	3.4	0.0	19.9	0.8
Whole enterprise profit	**9.2**	**19.8**	**20.7**	**24.7**	**-5.4**	**38.7**	**14.3**	**5.9**	**-2.8**	**7.9**	**5.5**	**40.6**	**5.2**
Gross margin/TVC ratio	2.5	1.0	0.6	0.3	0.7	1.5	0.5	0.8	0.7	0.2	0.6	3.6	0.8
Gross margin rate (%)	71.6	50.6	36.3	22.9	40.8	60.7	32.8	45.8	39.4	19.0	36.7	78.1	44.1

Table A10: Summary of costs and margins (KES) per litre of milk production for zero grazing model farms (large scale)

Production system	**Zero Grazing**	
County	**Nakuru 1**	**Tharaka Nithi**
Gross revenue from milk (sold +consumed)	**65.0**	**55.0**
Purchased fodder/pasture	0.0	1.6
Feed concentrates	16.3	14.4
Mineral salts	2.4	1.1
Water (purchased)	0.0	0.1
Health and breeding costs	1.3	0.8
Milking jelly	0.1	0.4
Hired labour	9.1	9.9
Repairs on fixed assets	0.4	0.3
Other costs (e.g. electricity, fuel)	0.3	0.6
Total variable costs (TVC)	**29.9**	**29.0**
Gross margin (revenue - TVC)	**35.1**	**26.0**
Depreciation (fixed assets)		0.5
Own fodder/pasture	14.4	13.0
Family labour	0.0	0.0
Total costs (TC = TVC + depreciation + own labour + own fodder)	**44.3**	**42.5**
Milk profits (revenue - TC)	**20.7**	**12.5**
Other revenue (sale of livestock, manure, bull services)	9.0	2.8
Whole enterprise profit	**29.7**	**15.3**
Gross margin/TVC ratio	1.2	0.9
Gross margin rate (%)	54.0	47.2

Table A11: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing model farms (small-scale farms)

County	Bungoma	Kakamega	Kiambu-Lari 1	Kiambu-Lari 2	Kisii	Migori	Nyeri-Kieni 1
Gross revenue from milk (sold +consumed)	48.4	75.0	48.9	47.0	50.0	47.0	40.9
Purchased fodder/pasture	0.0	3.1	0.0	1.3	1.7	0.6	0.0
Feed concentrates	3.9	2.4	8.1	15.9	3.3	5.2	3.5
Mineral salts	1.3	4.3	1.2	2.8	0.5	0.4	1.2
Water (purchased)	0.1	0.0	0.0	0.0	0.0	0.0	0.2
Health and breeding costs	3.7	4.6	2.0	2.1	1.2	6.2	2.4
Milking jelly	0.3	0.1	0.3	0.3	0.1	0.3	0.3
Hired labour	6.5	12.4	0.0	0.0	6.1	10.7	3.4
Repairs on fixed assets	0.4	0.5	0.3	0.1	1.3	0.9	0.1
Other costs (e.g. electricity, fuel)	0.1	0.0	0.3	0.0	0.0	0.0	0.6
Total variable costs (TVC)	**16.3**	**27.5**	**12.2**	**22.6**	**14.1**	**24.2**	**11.7**
Gross margin (revenue - TVC)	**32.1**	**47.5**	**36.6**	**24.4**	**35.9**	**22.8**	**29.2**
Depreciation (fixed assets)	3.8	0.4	0.2	1.0	1.1	0.6	0.2
Own fodder/pasture	18.6	8.7	14.1	17.8	6.5	7.3	24.2
Family labour	12.9	0.0	8.3	12.2	12.1	0.0	2.8
Total costs (TC = TVC + depreciation + own labour + own fodder)	**51.6**	**36.6**	**34.9**	**53.6**	**33.9**	**32.1**	**38.9**
Milk profits (revenue - TC)	**-3.2**	**38.4**	**14.0**	**-6.6**	**16.1**	**14.9**	**2.0**
Other revenue (sale of livestock, manure, bull services)	0.0	2.6	2.1	0.0	0.0	0.0	18.1
Whole enterprise profit	**-3.2**	**41.0**	**16.1**	**-6.6**	**16.1**	**14.9**	**20.1**
Gross margin/TVC ratio	2.0	1.7	3.0	1.1	2.5	0.9	2.5
Gross margin rate (%)	66.4	63.3	75.0	51.9	71.8	48.4	71.4

Table A12: Summary of costs and margins (KES) per litre of milk production for semi-zero grazing model farms (medium-scale farms)

County	Bomet	Elgeyo Marakwet	Narok
Gross revenue from milk (sold +consumed)	39.1	71.4	52.4
Purchased fodder/pasture	0.0	0.4	0.0
Feed concentrates	0.8	10.2	0.0
Mineral salts	3.1	1.0	0.9
Water (purchased)	0.0	0.2	0.7
Health and breeding costs	4.2	2.0	2.6
Milking jelly	0.3	0.1	0.1
Hired labour	3.1	3.5	7.2
Repairs on fixed assets	0.2	0.3	0.6
Other costs (e.g. electricity, fuel)	0.0	0.8	0.1
Total variable costs (TVC)	**11.7**	**18.3**	**12.3**
Gross margin (revenue - TVC)	**27.4**	**53.1**	**40.1**
Depreciation (fixed assets)	0.4	0.7	1.0
Own fodder/pasture	7.3	17.6	14.1
Family labour	11.4	2.5	14.5
Total costs (TC = TVC + depreciation + own labour + own fodder)	**30.8**	**39.1**	**41.9**
Milk profits (revenue - TC)	**8.3**	**32.2**	**10.5**
Other revenue (sale of livestock, manure, bull services)	2.8	0.7	0.0
Whole enterprise profit	**11.1**	**33.0**	**10.5**
Gross margin/TVC ratio	2.3	2.9	3.3
Gross margin rate (%)	70.0	74.4	76.6

Table A13: Summary of costs and margins (KES) per litre of milk production for open grazing model farms

Production system	**Open Grazing**
County	**West Pokot**
Gross revenue from milk (sold +consumed)	39.2
Purchased fodder/pasture	0.0
Feed concentrates	0.0
Mineral salts	0.2
Water (purchased)	0.0
Health and breeding costs	0.9
Milking jelly	0.1
Hired labour	0.0
Repairs on fixed assets	1.3
Other costs (e.g. electricity, fuel)	0.0
Total variable costs (TVC)	**2.5**
Gross margin (revenue - TVC)	**36.7**
Depreciation (fixed assets)	
Own fodder/pasture	17.5
Family labour	4.2
Total costs (TC = TVC + depreciation + own labour + own fodder)	**24.3**
Milk profits (revenue - TC)	**14.9**
Other revenue (sale of livestock, manure, bull services)	14.4
Whole enterprise profit	**29.4**
Gross margin/TVC ratio	14.6
Gross margin rate (%)	93.6

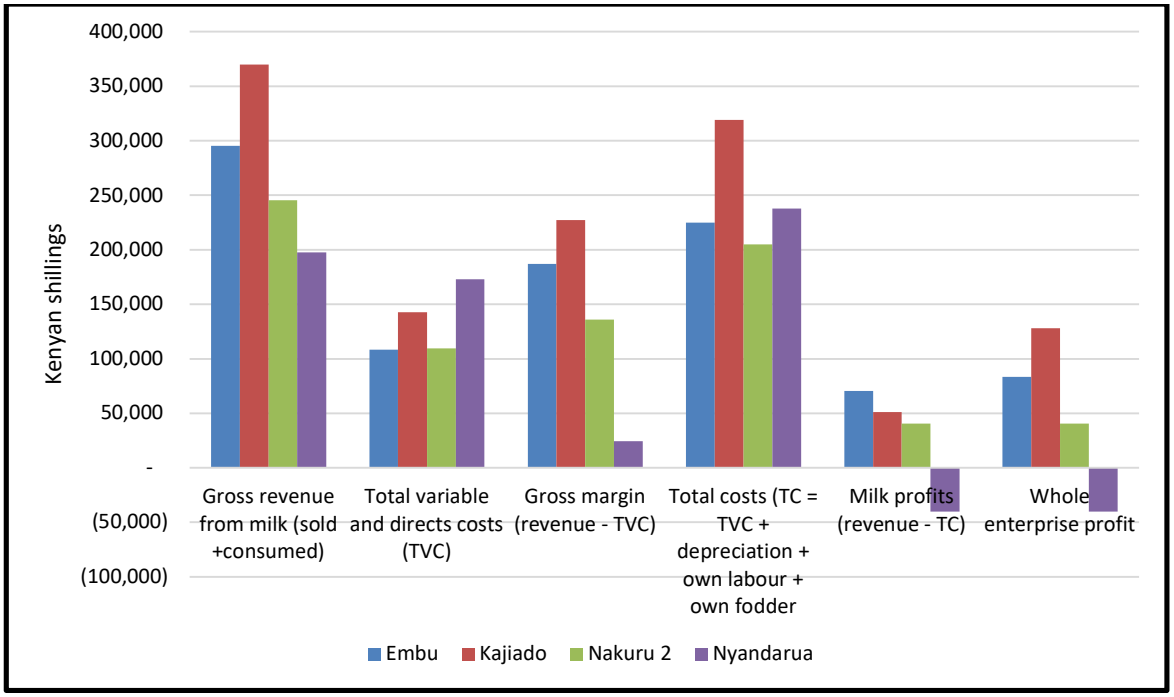

Figure A6: Costs and returns in KES per lactating cow per year for zero grazing model farms (small scale)

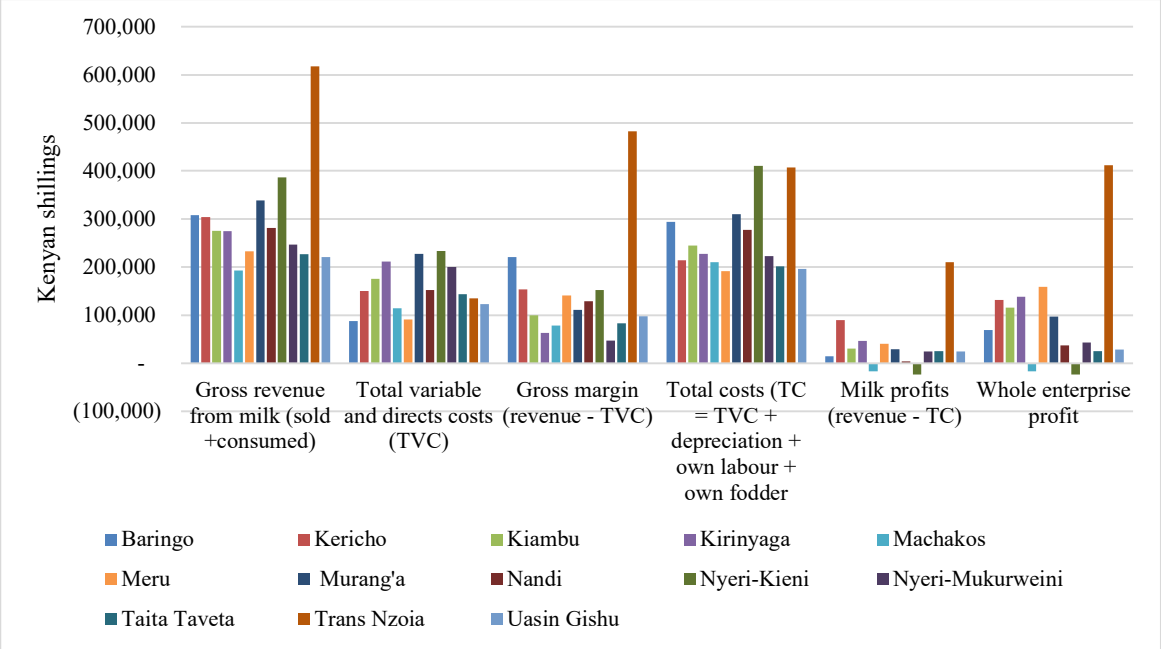

Figure A7: Costs and returns in KES per lactating cow per year for zero grazing model farms (medium scale)

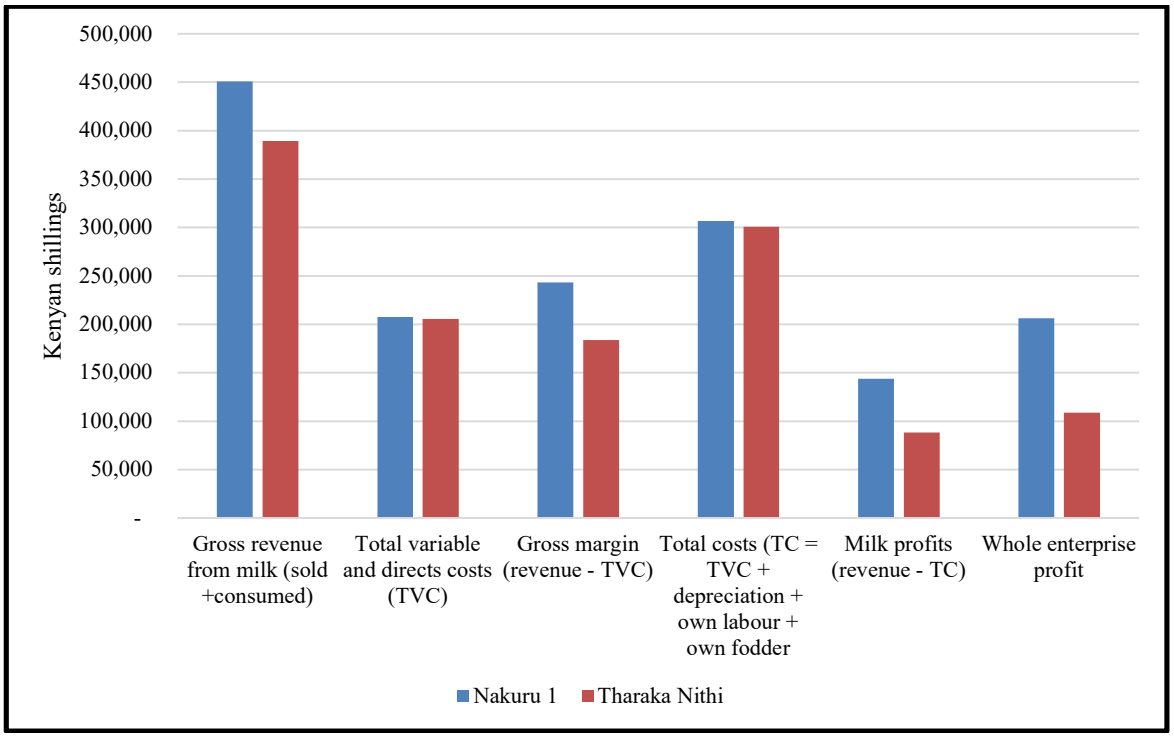

Figure A8: Costs and returns in KES per lactating cow per year for zero grazing model farms (large scale)

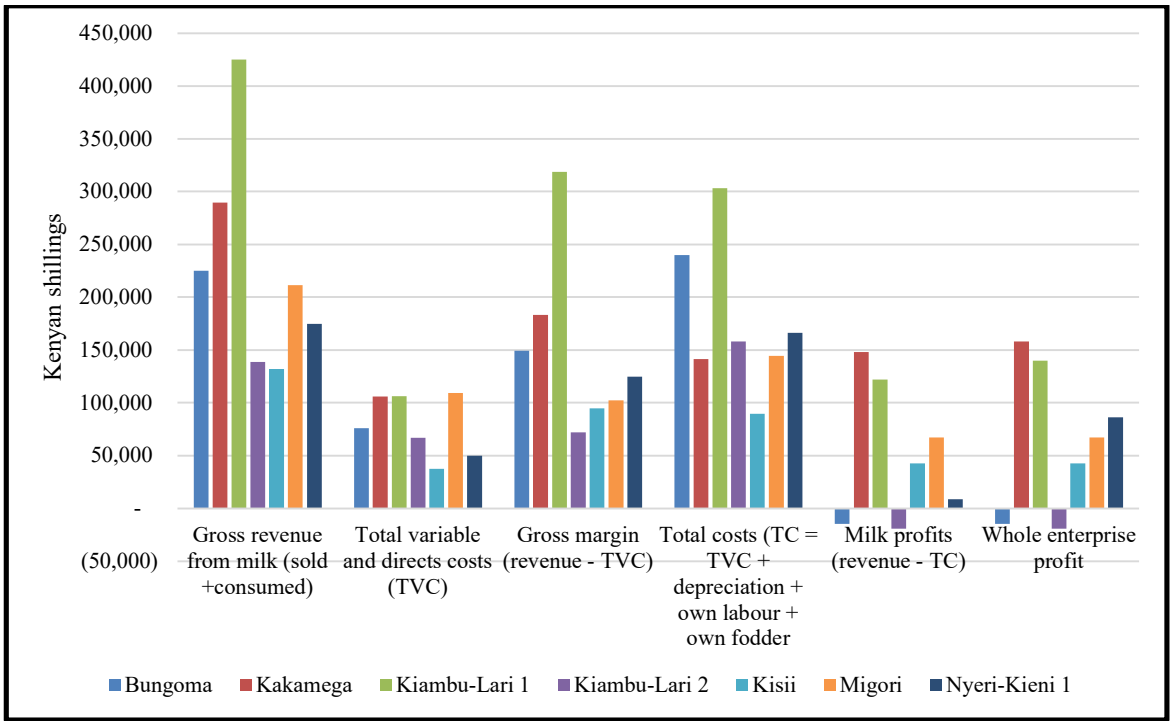

Figure A9: Costs and returns in KES per lactating cow per year for semi-zero grazing model farms (small scale)

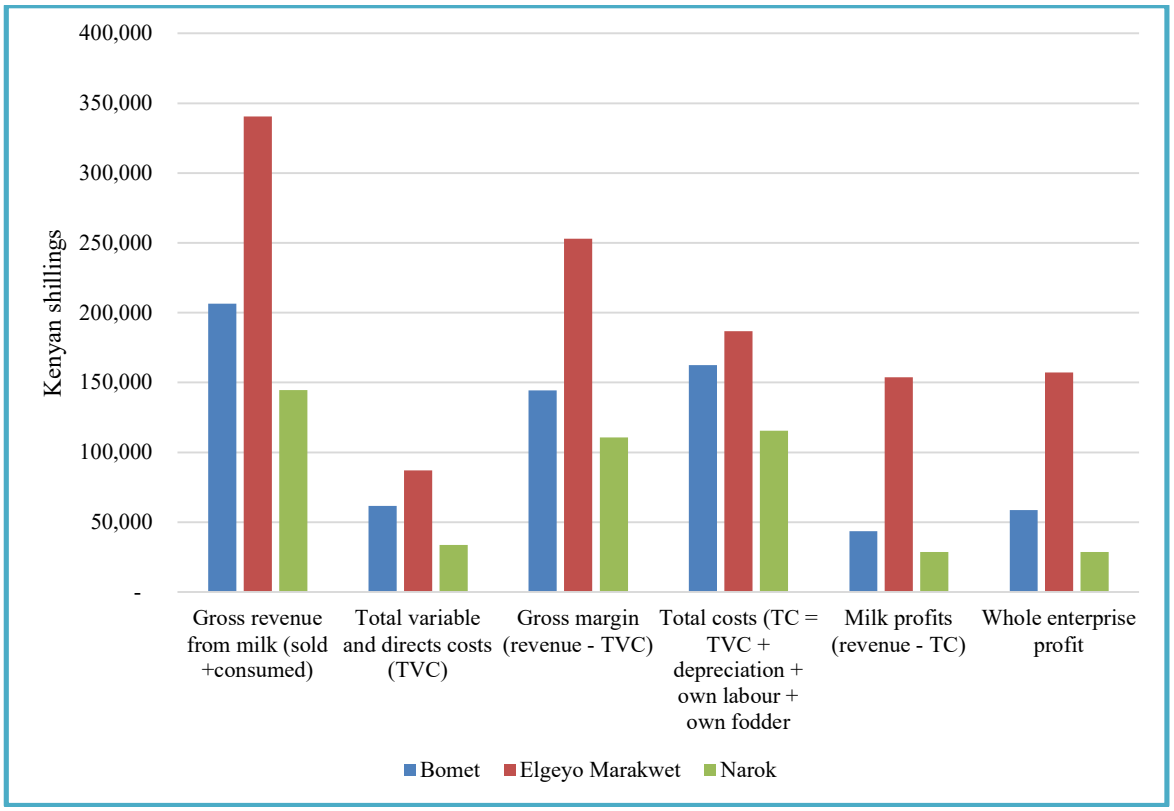

Figure A10: Costs and returns in KES per lactating cow per year for semi-zero grazing model farms (medium scale)

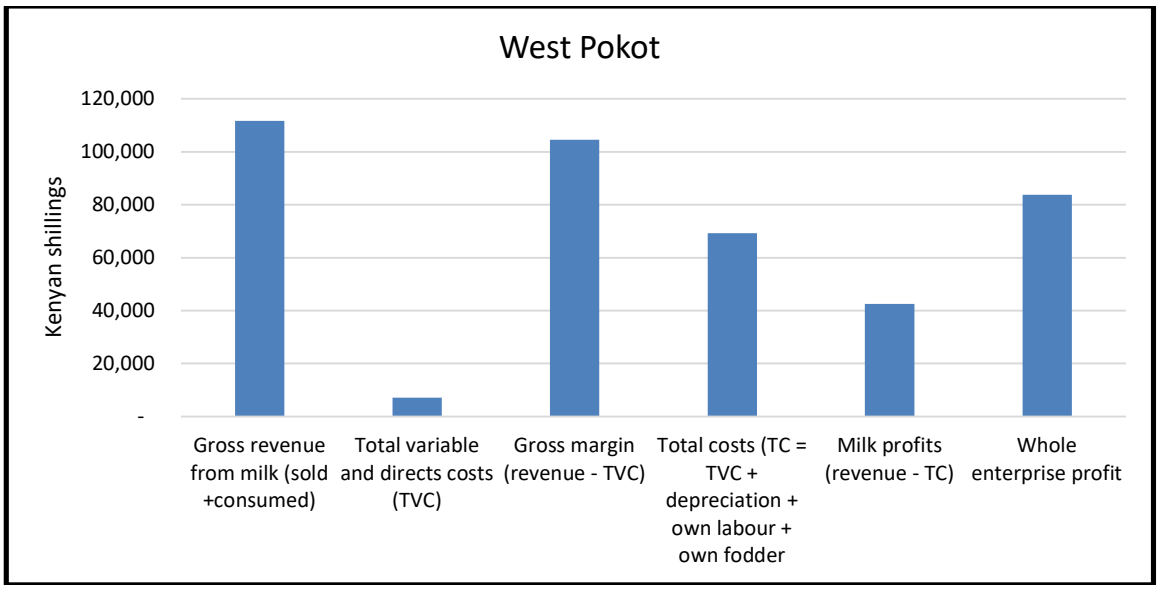

Figure A11: Costs and returns in KES per lactating cow per year for open grazing model farms (medium scale)

Table A14: Share of inputs in TVC for typical farms, by county (%)

County	*Purchased fodder*	*Feed con.*	*Mineral salts*	*Water (purchased)*	*Health & breeding costs*	*Milking jelly*	*Hired labour*	*Repairs of fixed assets*	*Other direct costs*
Baringo	0	80	2	1	15	1	0	1	0
Bungoma	0	0	0	0	69	8	0	23	0
Kakamega	11	33	7	0	34	3	0	11	0
Kisii	2	34	16	0	9	1	36	2	0
Migori	0	18	4	0	13	1	59	4	2
Nyandarua	0	52	4	4	21	2	0	6	10
Trans Nzoia	0	31	8	3	47	5	0	7	0
Bomet	0	52	9	0	6	1	29	3	0
Nandi	4	26	14	0	48	3	0	6	0
Uasin Gishu	0	25	21	0	25	2	26	1	0
Embu	23	59	3	1	8	1	0	3	3
Kajiado	13	36	22	3	6	1	18	1	0
Kericho	0	52	8	0	4	1	27	4	4
Kiambu	10	67	3	3	4	0	4	1	7
Kirinyaga	13	75	3	0	9	0	0	0	0
Machakos	41	0	0	5	7	2	38	5	3
Meru	0	77	5	1	13	1	0	1	1
Murang'a	47	30	5	1	3	1	11	1	3
Nyeri	21	64	3	2	4	1	0	2	4
Taita Taveta	35	40	3	1	19	0	0	2	0
Tharaka Nithi	14	53	4	1	14	2	0	7	4
Elgeyo Marakwet	0	0	67	0	27	2	0	4	0
Narok	0	0	26	0	42	4	0	27	0
West Pokot	19	0	0	6	63	5	0	7	0
Nakuru	0	52	13	0	32	2	0	2	0

Table A15: Share of inputs in TC for typical farms, by county (%)

County	*Purchased fodder*	*Feed con.*	*Mineral salts*	*Water (purchased)*	*Health & breeding costs*	*Milking jelly*	*Hired labour*	*Repairs of fixed assets*	*Other direct costs*	*Own fodder*	*Family labour*
Baringo	0	36	1	0	7	1	0	1	0	38	17
Bungoma	0	0	0	0	9	1	0	3	0	44	43
Kakamega	4	12	2	0	13	1	0	4	0	14	49
Kisii	1	23	11	0	6	0	24	1	0	20	13
Migori	0	10	2	0	7	0	31	2	1	22	25
Nyandarua	0	13	1	1	5	1	0	1	3	52	23
Trans Nzoia	0	7	2	1	11	1	0	2	0	40	37
Bomet	0	37	7	0	4	0	20	2	0	29	0
Nandi	1	5	3	0	8	1	0	1	0	32	50
Uasin Gishu	0	15	13	0	15	1	16	0	0	0	39
Embu	13	33	2	0	4	0	0	2	1	1	44
Kajiado	7	19	12	1	3	0	10	1	0	16	30
Kericho	0	37	6	0	3	1	19	3	3	29	0
Kiambu	8	51	3	3	3	0	3	0	5	10	13
Kirinyaga	6	35	1	0	4	0	0	0	0	6	47
Machakos	26	0	0	3	4	1	24	3	2	11	26
Meru	0	46	3	1	8	0	0	1	1	21	21
Murang'a	45	28	5	1	2	1	10	1	2	6	0
Nyeri	9	27	1	1	2	1	0	1	2	25	32
Taita Taveta	19	21	2	1	10	0	0	1	0	10	37
Tharaka Nithi	8	29	2	1	7	1	0	4	2	9	37
Elgeyo Marakwet	0	0	20	0	8	1	0	1	0	39	32
Narok	0	0	9	0	15	2	0	9	0	20	45
West Pokot	4	0	0	1	14	1	0	2	0	43	34
Nakuru	0	24	6	0	15	1	0	1	0	8	45

Table A16: Changes in TVC and returns as a result of reduction in costs and milk price increase for zero grazers

Item	**Embu**	**Kajiado**	**Kericho**	**Kiambu**	**Kirinyaga**	**Machakos**	**Meru**	**Murang'a**	**Nyeri**	**Taita Taveta**	**Tharaka Nithi**
% reduction in TVC as a result of 10% reduction in cost of:											
Feed concentrates	5.9	3.5	5.0	6.5	7.4	0.0	7.6	3.1	6.1	4.1	5.1
Purchased fodder/pasture	2.3	1.2	0.0	0.9	1.2	4.0	0.0	4.8	1.9	3.7	1.3
Health and breeding costs	0.7	0.5	0.3	0.2	0.8	0.5	1.2	0.3	0.1	2.0	1.2
Hired labour	0.0	1.8	2.6	0.3	0.0	3.7	0.0	1.1	0.0	0.2	0.0
% increase in GM as a result of 10% change in:											
Feed concentrates	7.6	2.4	8.3	13.1	3.7	3.0	3.6	10.3	5.4	5.4	3.0
Purchased fodder/pasture	3.1	1.4	3.0	2.8	0.6	6.2	0.0	14.0	2.0	4.9	0.8
Health and breeding costs	1.0	1.0	3.4	1.4	0.4	3.5	0.6	3.5	0.5	2.6	0.7
Hired labour	0.0	0.8	3.0	0.6	0.0	3.0	0.0	2.9	0.2	0.0	0.0
Milk price (increase)	19.3	12.7	17.7	23.9	13.1	15.5	13.0	27.6	15.9	19.9	13.8
% increase in milk profits as a result of 10% change in:											
Feed concentrates	7.6	1.6	5.6	12.4	3.7	0.0	3.6	7.8	5.4	5.4	3.0
Purchased fodder/pasture	3.1	0.5	0.0	1.9	0.6	3.2	0.0	11.7	2.0	4.9	0.8
Health and breeding costs	1.0	0.2	0.4	0.5	0.4	0.4	0.6	0.6	0.5	2.6	0.7
Hired labour	0.0	0.8	3.0	0.6	0.0	3.0	0.0	2.9	0.2	0.0	0.0
Milk price (increase)	**214.3**	19.5	28.7	48.8	26.9	26.8	18.2	31.3	**470.6**	**-220.6**	25.6

Table A17: Changes in TVC and returns as a result of reduction in costs and milk price increase for semi-zero grazers, small-scale

Item	Baringo	Bungoma	Kakamega	Kisii	Migori	Nyandarua	Trans Nzoia
	% reduction in TVC as a result of 10% reduction in cost of:						
Feed concentrates	8.0	0.0	3.3	3.4	1.7	5.2	3.1
Purchased fodder/pasture	0	0	1.1	0.2	0	0	0
Health and breeding costs	1.5	6.9	3.4	0.9	1.2	2.1	4.7
Hired labour	0	0.0	0.0	3.6	5.8	0.0	0.0
	% increase in GM as a result of 10% change in:						
Feed concentrates	3.9	0.0	1.0	5.5	1.5	1.6	0.7
Purchased fodder/pasture	0.1	0.0	0.3	0.4	0.0	0.0	0.0
Health and breeding costs	0.8	0.0	1.0	1.5	1.0	0.6	1.1
Hired labour	0.1	0.0	0.0	5.8	5.0	0.0	0.0
Milk price (*increase*)	13.1	10.4	11.5	21.3	15.9	11.5	11.0
	% increase in milk profits as a result of 10% change in:						
Feed concentrates	8.4	0.0	2.1	25.6	8.3	22.6	3.2
Purchased fodder/pasture	0.0	0.0	0.7	2.1	0.0	0.0	0.0
Health and breeding costs	1.3	0.0	2.2	8.2	5.7	10.6	4.7
Hired labour	0.0	0.0	0.0	26.5	23.3	0.0	0.0
Milk price (increase)	26.6	237.9	21.7	61.5	52.5	70.7	35.6

Table A18: Changes in TVC and returns as a result of reduction in costs and milk price increase for semi-zero grazers, medium scale

Item	**Bomet**	**Nandi**	**Uasin Gishu**
	% reduction in TVC as a result of 10% reduction in cost of:		
Feed concentrates	5.1	2.6	2.5
Purchased fodder/pasture	0.0	0.4	0.0
Health and breeding costs	0.4	4.8	2.5
Hired labour	2.7	0.0	2.6
	% increase in GM as a result of 10% change in:		
Feed concentrates	5.9	0.5	1.2
Purchased fodder/pasture	0.0	0.1	0.0
Health and breeding costs	0.0	0.9	1.2
Hired labour	0.0	0.0	1.2
Milk price (increase)	0.0	10.7	12.8
	% increase in milk profits as a result of 10% change in:		
Feed concentrates	11.1	6.1	4.3
Purchased fodder/pasture	0.0	0.9	2.7
Health and breeding costs	1.2	2.2	3.6
Hired labour	6.3	0.0	5.2
Milk price (increase)	30.4	60.7	19.9

Table A19: Changes in TVC and returns as a result of reduction in costs and milk price increase for open grazing grazers, medium and small-scale

	Medium scale				Small scale
Item	**Elgeyo Marakwet**	**Narok**	**West Pokot**	**Average (MS)**	**Nakuru**
	% reduction in TVC as a result of 10% reduction in cost of:				
Feed concentrates	0.0	0.0	0.0	0.0	5.2
Purchased fodder/pasture	0.0	0.0	1.9	0.5	0.0
Health and breeding costs	2.7	4.2	6.3	4.2	3.2
Hired labour	0.0	0.0	0.0	0.0	0.0
	% increase in GM as a result of 10% change in:				
Feed concentrates	0.0	0.0	0.0	0.0	2.7
Purchased fodder/pasture	0.0	0.0	0.3	0.1	0.0
Health and breeding costs	0.5	1.3	1.0	0.9	1.7
Hired labour	0.0	0.0	0.0	0.0	0.0
Milk price (*increase*)	10.5	11.5	10.4	10.8	13.5
	% increase in milk profits as a result of 10% change in:				
Feed concentrates	0.0	0.0	0.0	0.0	7.4
Purchased fodder/pasture	0.0	0.0	0.0	0.0	0.1
Health and breeding costs	1.0	**3.3**	2.5	1.5	4.8
Hired labour	0.0	0.0	0.0	0.0	0.0
Milk price (increase)	16.7	23.6	21.8	19.4	30.0

Table A 20: Average milk price per county for typical and model farms

	Typical farms		Model farms	
County	**Average price (KES)**	**Main buyer**	**Average price (KES)**	**Main buyer**
Embu	46	Dairy Cooperative	47	Dairy Cooperative
Kajiado	66.7	Traders	58.3	Dairy Cooperative
Kericho	46.3	Dairy Cooperative	46.7	Dairy Cooperative
Kiambu	48	Dairy Cooperative	49.9	Dairy Cooperative
Kiambu-Lari 1			48	Trader/ broker
Kiambu-Lari 2			47	Broker
Kirinyaga	50	Traders	49	Dairy Cooperative
Machakos	52.3	Traders	63.3	Dairy Cooperative
Meru	54.7	Dairy Cooperative	55	Dairy Cooperative
Murang'a	44.3	Dairy Cooperative	49.3	Dairy Cooperative
Nyeri	42.3	Dairy Cooperative	41.7	Dairy cooperative
Nyeri -Kieni 1			45	Dairy Cooperative
Nyeri -Kieni 2			50	School
Taita Taveta	45	Dairy Cooperative	43	Dairy Cooperative
Tharaka Nithi	55	Dairy Cooperative	55	Dairy Cooperative
Baringo	41.1	Dairy Cooperative	41.1	Dairy Cooperative
Bungoma	34	Dairy Cooperative	35	Dairy cooperative
Kakamega	75	Consumers	75	Consumer
Kisii	50	Private milk vendors	50	Broker
Migori	50	Private milk vendors	47	Dairy cooperative
Nyandarua	42.7	Dairy Cooperative		
Trans Nzoia	42.5	Dairy Cooperative	40	Consumers
Bomet	41.7	Dairy Cooperative	41.7	Dairy cooperative
Nandi	40.4	Dairy Cooperative	50	Consumers
Uasin Gishu	37	Dairy Cooperative	40	Dairy Cooperative
Nakuru	41.9	Dairy Cooperative	44.3	Trader
Nakuru 2			65	Processor
Elgeyo Marakwet	38	Dairy Cooperative	38	Hotels
Narok	33.5	Private milk Vendors	55	Dairy cooperative
West Pokot	36	Dairy Cooperative	35	Dairy Cooperative

Table A 21: Counties for the study in 2024

	County	**Milk production (litres), 2021**
1	Kiambu	344,354,667
2	Meru	342,865,787
3	Nyandarua	317,855,060
4	Nakuru	309,776,011
5	Uasin Gishu	218,262,327
6	Kakamega	217,504,108
7	Nandi	191,569,629
8	Trans-Nzoia	184,633,044
9	Embu	162,126,071
10	Murang'a	143,374,567
11	Bomet	136,322,662
12	Kericho	121,151,852
13	Nyeri	119,354,976
14	Kajiado	98,233,800
15	Bungoma	94,742,892
16	Narok	89,151,814
17	Elgeyo Marakwet	58,585,414
18	Kirinyaga	41,899,340
19	Tharaka Nithi	39,172,410
20	Baringo	35,241,159
21	Kisii	30,525,343
22	Machakos	27,954,235
23	T/Taveta	21,908,750
24	Migori	19,175,412
25	West Pokot	10,419,798

Source: Kenya Dairy Board, 2024

Table A 22: Comparison of counties for the study with the 2020 study

	Selected counties, 2020	**Selected counties, 2024**
1	Taita Taveta	Taita Taveta
2	Meru	Meru
3	Nyeri	Nyeri
4	Muranga	Muranga
5	Embu	Embu
6	Kiambu	Kiambu
7	Nakuru	Nakuru
8	Machakos	Machakos
9	Kisii	Kisii
10	Kakamega	Kakamega
11	Bomet	Bomet
12	Trans Nzoia	Trans Nzoia
13	Nyandarua	Nyandarua
14	Bungoma	Bungoma
15	Nandi	Nandi
16	Uasin Gishu	Uasin Gishu
17	Elgeyo Marakwet	Elgeyo Marakwet
18	Baringo	Baringo
19	Migori	Migori
20	Narok	Narok
21	-	Kericho
22	-	Kajiado
23	-	Kirinyaga
24	-	Tharaka Nithi
25	-	West Pokot