2022

VALUE CHAIN ANALYSIS REPORT

DAIRY VALUE CHAIN

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Executive Summary

Agriculture is seen as the primary contributor to Kenya's GDP at 34% and 65% of exports. The sector employs more than 40 percent of the total population and 70 percent of the rural population. Kenyan households that are exclusively engaged in agriculture contributed 31.4% to the reduction of rural poverty, and agriculture remains the largest income source for both poor and non-poor households in rural areas. Kenya has attained the lower-middle income status, with $100 billion Gross Domestic Product (GDP) and a diverse dynamic economy. It has the largest and fastest growing economy in Eastern and Central Africa. The government promotes the expansion of the agriculture industry through its policies and long-term plans. These plans of action include the Big Four Agenda, the Agriculture Sector Transformation and Growth Strategy (ASTGS), and the Vision 2030.

Throughout the world, more than six billion people consume milk and milk products, and the number is growing. At the same time, over 750 million people live in dairy farming households, particularly in emerging economies. Most dairy-farmers operate at a small-scale level; the global mean milk yield is 11 litres per farm per day, produced by an average number of two cows.

In Kenya, dairy is a vibrant sub-sector with an estimated value of 4.5% of the Agriculture GDP, and 12% to the national GDP, employing over 1.7 million citizens and growing at a rate of 5% per year. The sector provides livelihoods to about 1.8 million rural households, who produce about 80% of the total domestic milk. More than two million households in Kenya depend heavily on milk production for their income, and milk consumption generally contributes significantly to population health and nutrition. Dairy farming is a high-value industry that offers numerous prospects for smallholder development in the future. The Kenya's dairy industry is one of Sub-Saharan Africa's most developed.

FAO Kenya is designing a Green Climate Fund proposal titled Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc, Kenya (CRLCSA). To demonstrate feasibility of the selected value chains, CRLCSA has commissioned a value chain study. The study value chain analysis will assist the project design team to identify technologies, practices and business plans which have potential to assist the producers and value chain actors to reduce negative climate change impacts and improve their profitability.

Agriculture has been highlighted by the LVB region as one of the important growth industries, with the region's primary farming techniques comprising small-scale rain-fed farming, small-scale river irrigation, wetland farming, fish farming, and free-range animal rearing. Key crops farmed in the region are divided into cash crops and food crops. The agricultural sector in LBV is highly vulnerable to extreme weather events, climatic shocks, climatic changes, and variability. Climate change is creating further stresses on food and water supply while further degrading the environment.

The dairy cattle sector in Kenya is responsible for about 12.3 million tonnes CO2 eq. The GHG profile is dominated by methane (95.6 percent); nitrous oxide (N2O) and carbon dioxide (CO2) contribute 3.4 percent and 1 percent of the total emissions, respectively. At national level, the emission intensity of milk produced in Kenya is on average 3.8 kg CO2 eq./kg Fat-Protein Corrected Milk (FPCM); the highest values were estimated for extensive grazing systems and the lowest in semi-intensive systems. Emissions were on average, 7.1, 2.1, and 4.1 kg CO2 eq./kg FPCM for extensive, intensive, and semi-intensive systems, respectively.

Significant reductions in methane emission intensity can be realized through the adoption of existing and proven technologies and practices. Studies have shown that there is a high potential to reduce emission intensities; methane emission intensity (kg CO2 /kg FPCM) can be reduced by 7–45 percent, the magnitude of impact varies depending on the intervention and production system assessed. All interventions returned a positive productivity outcome with increases in milk production ranging between 4–80 percent.

The value chain analysis used mixed-methods approach including mainly qualitative data through varied techniques, desk reviews, key informant interviews and Focus Group Discussions. Review of documents related to the value chain assignment was done to get better insight of the value chain.

During the pre-independence era (from early 1900s to 1963), the sector was initiated and sustained by colonial white settler farmers, operating large-scale farms in the high potential highlands of Kenya. The colonial government established support institutions to develop the expanding export-oriented dairy industry such as veterinary laboratory and research stations, Kenya Creameries Cooperative (KCC), Central Artificial Insemination Services (CAIS) and the Kenya Dairy Board (KDB). The post-independence era, from 1963–1980s, saw significant changes in the dairy sector. Immediate post-independence era policies saw the sector rapidly shift towards domination by smallholders. Liberalization era marked the entry of new market players, mostly private sector investors in the development and delivery of services and inputs, such as feed production, veterinary services, breeding services, as well as milk processors and informal traders. After the withdrawal of subsidies and the monopoly combined with mismanagement, KCC gradually collapsed in 1999.

Dairy value chain has key nodes from input supply to consumption. The Milk production is dominated by small holder farmers estimated to be more than 1 million. In general, smallholders each have 3 to 5 acres. The average productivity per cow in Kenya is estimated to be 7-8 litres per day. The average production per lactation is between 2,000 litres and 2,400 litres. Of the milk produced, about 42% is consumed on-farm by calves and household members. Milk bulking facilities have grown to be significant commercial hubs for farmers, reducing the expense of milk collection from small, dispersed farmers by the major processing corporations. There are 92 dairy processors in the country, about 35 of which are large-scale companies producing a wide range of dairy products. Besides the processors, there are 128 registered mini-dairies and 173 cottage processors. Milk dispensing has emerged as a popular alternative source of milk, providing low-income consumers with quality milk at affordable prices. Milk consumption seems to be very income elastic; therefore, it can be anticipated to increase when per capita income, population, industrialization, and urbanization all increase.

Milk production goes to satisfy local demand while net imports represent only about 0.5% of total milk produced in Kenya. The free movement of dairy products within the East African Community (EAC) and the tripartite regional agreements between the EAC, Common Market for Eastern and Southern Africa (COMESA), and Southern African Development Community (SADC) that facilitate regional trade make a regional market for Kenyan dairy products widely accessible.

Dairy has a link with natural environment like water where the highest proportion of water utilized along the dairy value chain goes into feed production. Water is also used during milking, cleaning, and cooling of animals. Grazing is vital for the conservation of habitats and species in traditional habitats. Cultivating a diverse range of plant species and varieties for grass forage increases the diversity of the agricultural environment hence contributing to biodiversity.

Climate change has adverse effects on dairy value chain, rise in temperature influence milk quality, increase occurrence of diseases among other challenges. The agricultural sector is the largest source (58.6%) of total GHG emissions in Kenya, and livestock related emissions account for the overwhelming majority (96.2%) of those emissions. The difficulties faced by small-scale dairy farmers in Kenya are anticipated to get worse because of climate change and global warming, which will increase crop failure and drought while making it difficult for many plant and animal species to adapt.

Dairy value chains have competitive advantages like; Nationwide availability and steadily increasing variety of dairy products for all consumer groups, Ongoing investments in value-added products, including long-life milk and milk

powder among others. It also faces some weaknesses like; High cost and seasonality of raw milk production due to low ability/skills to produce and preserve quality Fodder, high cost of milk collection and cold chain development among others.
The dairy industry is estimated to generate 76 jobs for every 1000 litres of milk sold. Specifically, at the input and production level, about 23 full-time self-employed jobs, 50 permanent full-time jobs for employees and 3 full-time casual jobs are generated. Poor infrastructure, including a lack of electricity, water, and road networks, also prevents the dairy industry from expanding and generating jobs.

Currently over 10 million people in Kenya suffer from chronic food insecurity and poor nutrition, and between two and four million people require emergency food assistance at any given time. Food safety is critical to good health and nutrition status. Milk is regarded as a whole food, providing energy, protein, vitamins, and minerals in the human diet. It can therefore correct for malnutrition and nutrient deficiencies especially in children and young adults.
The roles played by men and women in the dairy value chain are influenced by the gender division of labour and therefore tend to vary depending on the prevailing milk production and marketing systems. Women play a predominant role at the production node, taking care of cattle, milking, processing, and marketing milk while men, and to some extent children, play supportive roles as family members or hired labour.

1 Introduction

1.1 Background and objectives of the value chain analysis

Kenya has attained the lower-middle income status, with $100 billion Gross Domestic Product (GDP) and a diverse dynamic economy (USAID 2022). It has the largest and fastest growing economy in Eastern and Central Africa (Akinwui, 2021)[1].

Agriculture is seen as the primary contributor to Kenya's GDP at 34% and 65% of exports (World Bank, 2018). The sector employs more than 40 percent of the total population and 70 percent of the rural population (USAID, 2022). Kenyan households that are exclusively engaged in agriculture contributed 31.4% to the reduction of rural poverty, and agriculture remains the largest income source for both poor and non-poor households in rural areas (World Bank, 2019)[2].

In Kenya agriculture is also the main driver of the non-agricultural economy including manufacturing, providing inputs and markets for non-agricultural operations such as construction, transportation, tourism, education, and other social services (FAO, 2022).

The Government supports agricultural sector growth through policies and strategic blueprints. Among these policies and strategic blueprints are the Vision 2030, the Agriculture Sector Transformation and Growth Strategy (ASTGS) and the Big Four Agenda. These agricultural policies share a common goal of increasing productivity and income growth among smallholder farmers to enhance food security and equity and create employment opportunities.

The dairy value chain is one of the key value chains in the sector contributing about 4% to the national GDP. FAO Kenya is designing a Green Climate Fund proposal titled Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc, Kenya (CRLCSA). To demonstrate feasibility of the selected value chains, CRLCSA has commissioned a value chain study. The study value cha will assist the project design team to identify technologies, practices and business plans which has potential to assist the producers and value chain actors to reduce negative climate change impacts and improve their profitability.

1.1.1 Global, National and County overview of the value chain

Approximately 150 million households around the globe are engaged in milk production. In the last three decades, world milk production has increased by more than 59 percent, from 530 million tonnes in 1988 to 843 million tonnes in 2018[3].

The value of the dairy market worldwide was estimated to be about 871 billion U.S. dollars, which is projected to grow to 1,128 billion dollars by 2026[4].

[1] Akinwui, A. (2021). African Economic Outlook 2021: From debt resolution to growth - The road ahead for Africa. In African Development Bank Group.

[2] Kenya Economic Update: Transforming Agricultural Productivity to Achieve Food Security for All, World Bank, 2019

[3] Gateway to dairy production and products, FAO

[4] Global dairy industry - statistics & facts

In Kenya, dairy is a vibrant sub-sector with an estimated value of 4.5% of the GDP, and 12% to the national GDP, employing over 1.7 million citizens and growing at a rate of 5% per year[5]. Kenya government has prioritised dairy among the productive sectors in the country's vision 2030 blueprint and the Agriculture Sector Transformation and Growth Strategy (2019-2029).

The dairy value chain has been identified as one of the key sectors to be supported by the CRLCSA program in the Lake Region Economic Bloc (LREB)Counties. The key Counties where dairy has been identified as a key value chain in the LVB region are Kisii, Kericho, Kisumu, Migori, Nyamira, Transzoia, Vihiga, Kakamega and Homabay.

1.1.1 Key statistics on value chain performance (production, productivity, industry and market trends

The sector provides livelihoods to about 1.8 million rural households, who produce about 80% of the total domestic milk. The sector has been growing at an estimated rate of between 3–4% annually. The contribution of cattle milk has been growing with increased total national milk production. Reliable statistics estimate that the country has close to 6.8 million dairy cattle, of which 3.2 million are lactating annually[6]. Figures 1 and 2 below show milk production and formal milk marketing respectively.

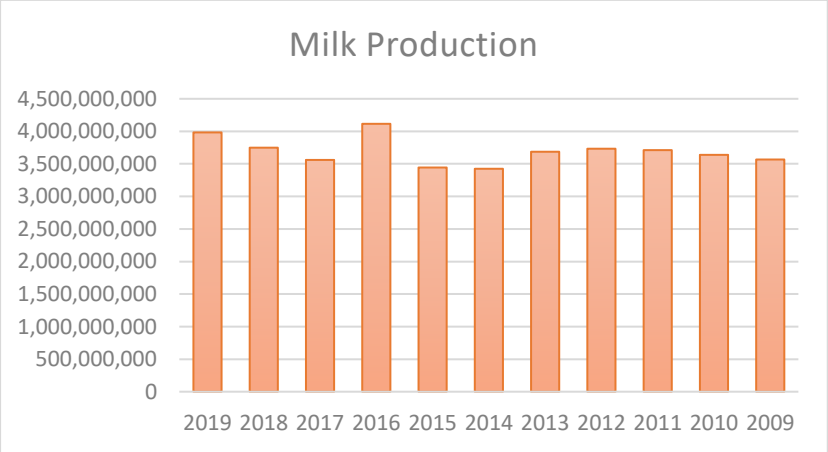


Figure 1: Milk Production figures (2009-2019)

Source:[7]

[5] Ministry of Agriculture, Livestock and Fisheries, 2019

6 Auma, J., Kidoido, M. and Rao, J. 2017. Feed the Future Accelerated Value Chain Development (AVCD) Program: Dairy component value chain analysis. Nairobi, Kenya: International Livestock Research Institute (ILRI).

[7] Kenya Dairy Board Website

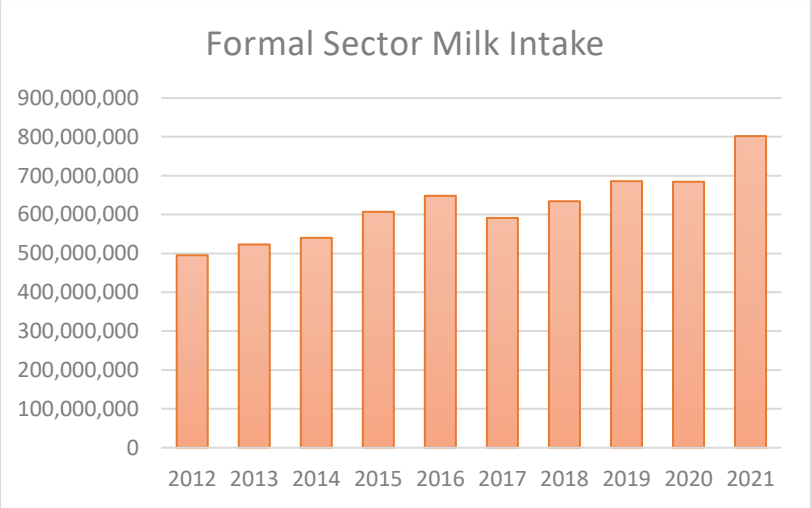


Figure 2: Formal Sector Milk Intake 2012-2021

Driven by growing urban demand, national per capita milk consumption is expected to grow at an annual rate of 2.8 percent for the next ten years, from 106 liters per person in 2012 to 139 liters by 2022. The total national milk consumption will grow at 6 percent per year to reach 8.0 billion liters, because of population growth. Our analysis suggests that urban milk demand will grow at an annual rate nearly double that of rural demand over the same period to 3.91 billion liters. Kenya will require an additional 3.52 billion liters of milk by 2022 (79 percent over the 2012 levels) to satisfy demand, with urban areas accounting for 59 percent of the total growth[8].

Previous estimates have shown that small scale producers were producing between 70% and 80% of the milk while the large-scale dairy farming was accounting for between 30% and 20% of the national milk production[9]. The dairy value chain is broadly divided into informal and formal market channels, based on compliance with regulatory frameworks for quality and safety standards and payment of statutory revenues[10].

1.1.2 Reason for chain selection

Despite great potential, Kenyan smallholder dairying faces diminishing land sizes, high input costs, poor extension contacts, non-responsive price policies, and new pests and diseases. Climate change will worsen the situation[11].

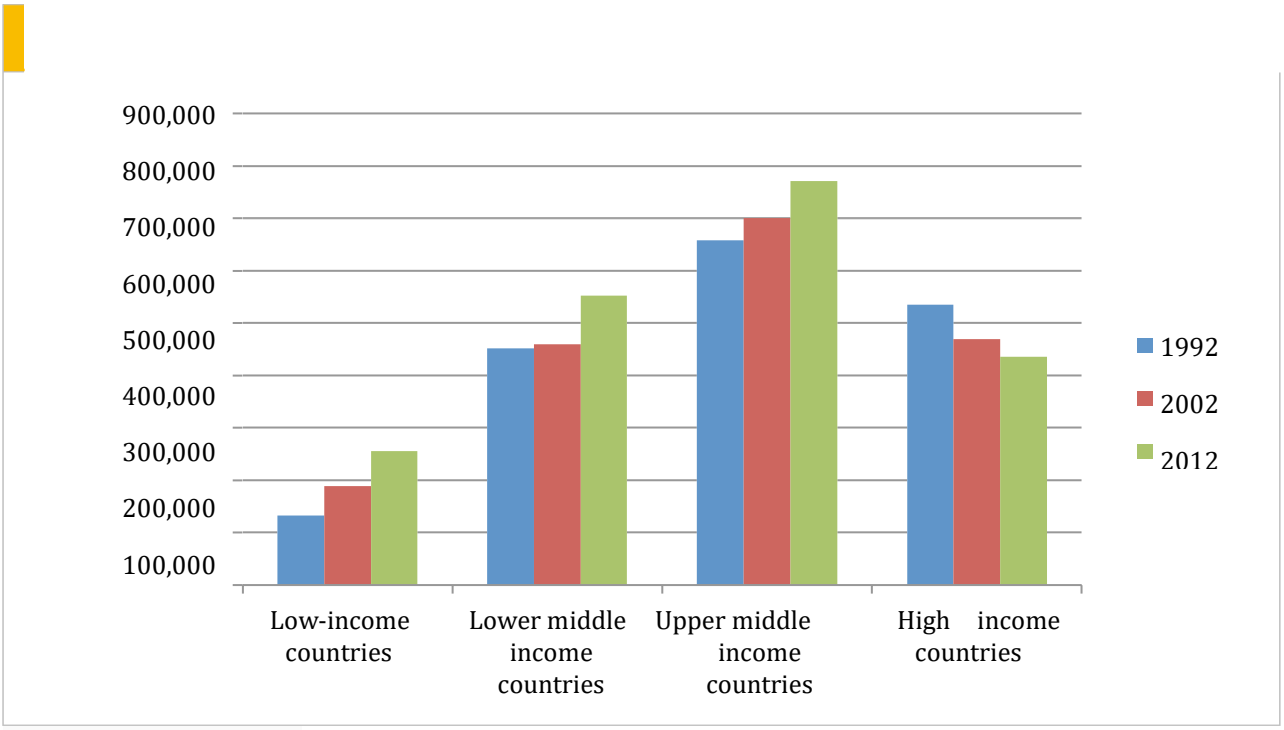
[8] USAID-KAVES Dairy Value Chain Analysis, 2014August

[9] Milk Production and marketing 2013

[10] Sustainable growth of the Kenyan dairy sector A quick scan of robustness, reliability, and resilience, Rademaker et al, 2016

[11] Adaptation of Smallholder Dairy Farmers in South Western Kenya to the Effects of Climate Change Charles Okech Odhiambo, Harun Okello Ogindo, Chlirukovian Bwire Wasike, Washington Odongo Ochola

Global warming and the associated climate change is expected to exacerbate the challenges smallholder dairy farmers in Kenya face, as it would lead to more crop failure and famine, with many plant and animal species having problems adapting[12].



Source: Van Dijk et al, 2015

Livestock supply chains are a significant source of global greenhouse gas (GHG) emissions and emit an estimated 7.1 gigatonnes of carbon dioxide-equivalents per year, representing approximately 14% of all human-induced emissions[13] . GHG emissions of the livestock sector are mainly comprised of methane (44%), nitrous oxide (29%) and carbon dioxide (27%). Enteric fermentation, a natural part of the digestive process for many ruminant animals, accounts for 39% of livestock sector emissions. Other significant sources of emissions are feed production and processing (45%) and manure storage (10%). The remaining 6% of GHG emissions is attributable to the processing and transport of livestock products[14]

The livestock sector has a large potential to reduce greenhouse gas emissions. Mitigation (reduction or prevention) of the sector's emissions could be achieved by a reduction in production or consumption, by an increase in production efficiency to reduce emissions per livestock product, or by shifting the structure of production towards less emission-intensive animal food types.

The dairy cattle sector in Kenya is responsible for about 12.3 million tonnes CO2 eq. The GHG profile is dominated by methane (95.6 percent); nitrous oxide (N2 O) and carbon dioxide (CO2) contribute 3.4 percent and 1 percent of the total emissions, respectively. At national level, the emission intensity of milk produced in Kenya is on average 3.8 kg CO2 eq./ kg FPCM; the highest values were estimated for extensive grazing systems and the lowest in

[12] Ibid
[13] van Dijk S, Tennigkeit, T, Wilkes A. Climate-smart livestock sector development: the state of play in NAMA development. CCAFS Working Paper No. 105. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark
[14] Ibid

semiintensive systems. Emissions were on average, 7.1, 2.1, and 4.1 kg CO2 eq./kg FPCM for extensive, intensive, and semi-intensive systems, respectively[15]

Significant reductions in methane emission intensity can be realized through the adoption of existing and proven technologies and practices. Studies have shown that there is a high potential to reduce emission intensities; methane emission intensity (kg CO2 /kg Fat-Protein Corrected Milk (FPCM) can be reduced by 7–45 percent, the magnitude of impact varies depending on the intervention and production system assessed.

The Interventions chosen have to have potential for improving productivity while at the same time reducing enteric CH4 emissions per unit of output and have to be feasible in the short or medium term. Improved practices and technologies such as strategic supplementary feeding, and improving the diet quality, adequate animal health control, and improved animal husbandry practices are some of the techniques that can improve dairy productivity and reduce emission intensity.

Applying combinations of interventions 'packages' aimed at improving feed availability and quality (Establishment of fodder grasses and legumes, use of conserved silage and UMMB); improving herd health (vaccination against East Coast Fever) and improved genetics (artificial insemination) can potentially result in a reduction potential of 21–36 percent in emission intensity relative to the baseline emission intensity. All interventions returned a positive productivity outcome with increases in milk production ranging between 4–80 percent. With these combinations of technologies, an increase in milk production of 31–35 percent can be achieved[16].

The Kenyan Government has also set ambitious targets in relation to Climate Smart Agriculture (CSA), centred on adaptation and resilience; reduction of greenhouse gas emissions; legal, policy and institutional strengthening; and addressing cross-cutting issues that affect CSA.

Dairy production, just like other agriculture sectors in Kenya is largely subsistence oriented, reliant on low external input use, limited technology uptake, lack of adequate financial and extension services. The situation is compounded by more severe and frequent drought and flood risks (USAID, 2021). Faced with multiple challenges, domestic milk production is failing to satisfy a growing demand. Production costs are high due to high cost of inputs and services, increased transaction costs by brokers and low labour and farm productivity (Kessler et al., 2020).

Other challenges include low milk quality due to poor milk hygiene practices leading to high milk rejections at farm and producer organization levels in dairy. Dairy competitiveness in the region is low, despite a growing domestic demand from rising middle class population, urbanization, and export opportunities (Kessler et al., 2020; Rijn, 2016). Interventions to accelerate growth are needed and include reviewing policy priorities, harnessing farmer knowledge and organization, empowering marginalized groups, supporting agriculture financing, and embracing digital innovations[17].

Along the Lake Region Economic Bloc (LREB), mean temperatures oscillate between 16-18°C with maximum temperatures reaching 25-30°C[18]. The LVB's average surface temperature increased between 1980 and 2010 by 0.5-0.7°C, with an increase rate of 0.21°C per decade, particularly during the long rainy season (MAM) in the arid

[15]FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2017. *Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods*. Rome. 43 pp.

[16] Ibid

[17] Agricultural productivity in Kenya: barriers and opportunities, Birch 2018

[18] Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc, Kenya (CRLCSA)Prefeasibility Study, 2022

and semi-arid regions[19]. Inland areas have experienced higher increases in both minimum and maximum temperatures. Maximum temperatures have increased by 0.75-1°C from 1980 to 2005 in the LREB, with a yearly increasing rate of 0.03-0.04°C[20].

The rise in temperature has negatively affected the agricultural sector. Firstly, temporal, and spatial variability in rainfall have resulted in a decrease in agricultural productivity in the LVB[21]. This decrease in productivity is widespread as rain-fed agriculture is practiced by 60% of the population in the LVB and contributes ~34% to the national GDP[22]. Secondly, increased annual temperatures have resulted in heat stress in livestock, which reduces growth rates, reproductive rates, milk production as well as the health and welfare of livestock animals[23]. Therefore, climate change is contributing to food insecurity in the LVB and increasing the vulnerability of people whose livelihoods are underpinned by agriculture.

1.2 Methodology

1.2.1 Mixed methods approach (qualitative and quantitative methods)

The analysis will use a mixed-methods approach including mainly qualitative data through varied techniques including literature/desk reviews, key informant interviews, Focus Group Discussions, and interviews.

1.2.2 Desk Research

Thorough literature review of all documents related to the review assignment (Subject to availability) to get a better insight of the research and to sharpen the research processes.

1.2.3 Key Informant Interviews

The secondary data research was complemented through qualitative interviews with key informants. This generated insights to get in-depth information on county level data on the value chain.

1.2.4 Focus Group Discussion

A qualitative focus group discussion guide will be developed that will seek to generate insights. Data generated from the FGDs will be triangulated with data collected from other sources to offer explanations for trends and insights observed.

1.3 History of Value Chain

1.3.1 Brief history of the value chain

There are three main periods in the development of the dairy sector in Kenya, i.e., the period of steady growth (before 1990), disruption (1991-2002), and the period of revival (since 2003). During the period of steady growth, indigenous smallholder farmers were encouraged to develop dairy production through training, infrastructural development, and service delivery. Annual milk production grew from 75 million liters in 1964 to 392 million liters in 1990. During the period of disruption, dairy production declined from 359 million liters in 1991 to less than 150 million liters in 2002, due to the absence of an efficient market and supply system. During the revival period,

[19] WBG, 2021: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15724-WB_Kenya%20Country%20Profile-WEB.pdf

[20] Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc, Kenya (CRLCSA), Prefeasibility Study

[21] East African Sustainability Watch Network 2014. Lake Victoria climate change readiness brief, No.3.

[22] Ibid

[23] East African Sustainability Watch Network 2014. Lake Victoria climate change readiness brief, No.3

the dairy sector experienced a sharp increase in the volume of production, reaching over 4.1 billion liters in 2014 (FAO, 2011).

Kenya dairy sector, facts & figures
Total milk production: 5.2 billion kg (2021)
Production by smallholders: 80 % Milk processed: 30 %
Raw milk market: 70 %
Smallholders: 800.000
Medium / large scale farms: 3500
Milk consumption / capita: 115 litres/year
Active milk processors: 30
Market leader in milk processor: Brookside
Income and employment in the dairy value chain for 1.8 million people

Source[24]

Commercial dairying was introduced into Kenya in the early twentieth century, but indigenous Kenyans were not involved in it until the mid-1950s. After independence, most dairy cattle were transferred to the indigenous people, marking the beginning of smallholder domination of the dairy industry. The policy environment for dairy can be divided into four phases: i) pre-independence (before 1963), export-oriented and large-scale; ii) first administration after independence (1967 to 1978), growth of smallholders; iii) second administration after independence (1979 to 2002), period of disruption; and iv) since 2003, period of new impetus[25].

During the pre-independence period, KCC was formed in 1925 with the aim of processing and marketing milk produced by the settler dairy farmers, indigenous Kenyans were not allowed to engage in commercial dairy farmers until 1954 when a production quota was allocated to them by the Swynnerton plan. In 1958 Kenya Dairy Board (KDB) was established to enforce regulations in milk marketing.

In the post-colonial period, land ownership reforms resulted in acquisition of large-scale agricultural farms from the while settlers by small scale farmers. In 1964, the Dairy Industry Development Commission opened up KCC to all dairy producers by abolishing the milk delivery quota system. The government-maintained policies inherited from the colonial government which included provision of extension, veterinary and artificial insemination services.

The dairy market liberalization period brought about policy changes that led to an increase in private sector participation and government divestiture. Services such as AI, veterinary clinical services and tick control were liberalized in line with Sessional paper No. 1 of 1986 on Economic Management for Renewed Growth. The removal of government support led to a decline of dairy production as many farmers could not afford the high cost of services. Milk marketing was liberalized following recommendations in the dairy master plan of 1991. The move ended the monopoly of KCC which went bankrupt in 1999 with farmers losing money in non-payment for milk delivered. This led to the emergence of private processors and itinerant traders buying milk at very low prices affecting the viability of the industry.

Despite these setbacks, the industry has continued to witness growth with commercialization at all nodes of the chain gaining momentum. The government, private sector and development partners players have continued to invest at all levels of the value chain.
such as supply of inputs, breeding, veterinary and credit services.[26]

[24] Ettema, F, 2015. Dairy Development in Kenya
[25] FAO, 2011, Dairy Development in Kenya
[26] sessional paper no. 5 of 2013 on the national dairy Development policy, MOALF

1.3.2 Previous development activities

The dairy sector in Kenya has been supported through different development initiatives over the years. More recent programs include the Kenya Market Led Dairy Program (KMDP) implemented by SNV funded the Dutch Ministry of Foreign affairs that focused on improved productivity and quality of milk; Kenya Agricultural Value Chain Enterprises (KAVES) aimed at enhancing food security, improving nutrition and increasing economic opportunities for women, youth and other vulnerable populations; Kenya Crops and Dairy Market Systems (KCDMS) Activity implemented by RTI, Heifer International Food For All and Kenya Market Led Dairy Supply Chain Project **(**KEMDAP). Projects that have had a deliberate focus on climate change are the Kenya Climate Smart Agriculture Project (KCSAP) funded by the World Bank and implemented in 24 Counties; Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes in Kenya's Arid and Semi-Arid Land's (ICSIAPL) program implemented by SNV and KALRO in Narok, Kajiado and Taita Taveta.

Other notable interventions include: the Smallholder Dairy Project jointly implemented by the Ministry of Livestock Development (MoLD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI), with primary funding from the UK Department for International Development (DFID); the USAID (United States Agency for International Development) Kenya Dairy Sector Competitiveness Program (KDSCP) which was a 5-year effort to improve Kenya's dairy industry competitiveness, and implemented by Land O'Lakes, Inc., with financial and technical support from USAID; IFAD funded Smallholder Dairy Commercialization Programme (SDCP) which was implemented by the Ministry of Livestock Development; East African Dairy Development (EADD) Programme funded by the Bill and Melinda Gates Foundation and implemented by the Heifer Project International, TechnoServe and ILRI; Heifer International dairy project in parts of the Rift Valley and Central Province through gifts of income-producing animals and training; and, the Kenya Dairy Project (KDP) funded by private donors and implemented by Technoserve Inc. in Nyala in Nyandarua North, Sabatia Dairy Farmers Cooperative in Eldama Ravine, Ndumberi Dairy Farmers in Kiambu and Muki Dairy in North Kinangop (Land O' Lakes, 2008).

In the LVB region, recent development activities have been supported through Heifer International, the World Banks KCSAP and NARIGP, IFAD and NCBA CLUSA among others. The programs have had a focus on improved productivity, milk quality and group organization and organizational development for farmer groups. KCSAP has had a particular focus on climate smart practices with introduction of Technologies, Innovations and Management Practices (TIMPs).

Climate Financing[27]

In terms of climate financing the Kenya government is implementing a 5-year Financing Locally Led Climate Action (FLLoCA) Program. The FLLoCA Program seeks to address the financing gap while building resilience at the community level. Specifically, the Program's objectives are to:

1. Support the development and strengthen policy, legal and regulatory frameworks at national and county levels for accelerated access to climate financing for building resilience at local levels;
2. Strengthen the capacity of national and county level institutions and stakeholders to accelerate climate financing at the local level;
3. Increase access to climate finance to support investments in climate resilience and low carbon emissions at the local level (urban & rural);

[27] Financing locally led climate action (FLLoCA) Program, County readiness assessment report. Strengthening the capacity of counties to access climate finance, The Treasury and Planning 2021

4. Support community-led local initiatives for enhanced community resilience and enhanced sustainable development;
5. Increase access to green/environmentally friendly technologies to deliver low carbon climate-resilient development at national and local levels; and
6. Enhance transparency and accountability on the support provided and actions implemented.

In 2021 the government conducted an assessment of the status of implementation of the program in the counties on 6 components: Policy, Legal and Institutional Framework, Capacity Building, Climate Finance Results Framework, Supporting Community-Led Actions, Technology and Innovation, Monitoring, Reporting, and Verification Plus (MRV+)

The assessment provided critical insights into the state of preparedness by the counties to implement locally-led climate change actions. A majority of the counties have requisite legal, policy and institutional frameworks that are necessary to support the achievement of the FLLoCA program objectives. The findings indicate that most of the counties have a designated CECM in charge of Climate Change and established functional county and community level institutions. However, there remains capacity gaps particularly with respect to the development of climate change and climate finance policies, and the establishment special purpose account for the CCCF.

The FLLoCA Program emphasizes the need for the counties to have climate change actions plans for the purposes of identifying, prioritizing and mainstreaming climate change adaptation and mitigation actions. The assessment revealed that less than half of the county governments had put in place climate change action and adaptation plans possibly due to slow adoption of climate change-specific programming by the counties. However, more than three quarters of the counties have mainstreamed green technologies.

To enhance county readiness to identify, prioritize, implement and monitor locally led climate actions, the report recommended that the FLLoCA Program in collaboration with County Governments, relevant MDAs and other community stakeholders responsible for climate actions should:

1. Strengthen the capacity of the county governments to formulate, enact and operationalize the necessary policy and legal frameworks to enable implementation of climate actions.
2. Support the establishment and operationalization of County Climate Change Funds and the requisite institutional arrangements for the management of the Funds.
3. Strengthen coordination mechanisms between national, county and community institutions and stakeholders to enhance implementation of locally led climate actions.
4. Strengthen the capacity of county governments to track and report local climate change actions and climate finance flows.
5. Encourage prioritization and mainstreaming of climate change and adaptation actions in the county planning processes.
6. Develop strategies and programs to promote private sector participation in local level climate investments and mobilization of resources.

2 Functional Analysis

2.1 Value Chain Map

Figure 3: Dairy value chain map

Source[28]

The value chain has 6 key nodes from input supply to consumption. Each node is described in brief in the sections below.

2.1.1 Dairy inputs and services supply

The use of inputs is low but varies depending on community traditions and the level of market orientation. Some of the important dairy inputs are discussed below.

Feed/fodder production | Most fodder is produced on farm with a significant number of farmers using nappier grass as the basal feed. Crop residues such as maize stovers and bean stalks are also used as animal feed. However new improved fodder varieties including grasses such as bracharia and panicum; and legumes such as lucerne and desmodium have been introduced to small holder dairy farmers. Adoption of crops used for silage preparation including maize and sorghum are also on the increase. Many farmers in the LVB region practice semi-intensive and intensive systems of production.

Another SCP practice is feed formulation, which depends on the type of animal, feed, and region. A dairy farmer can mix different feed ratios to ensure that the animal gets all the essential nutrients in appropriate quantities, thus preventing over-or under-feeding. These SCP practices will address the feeding and low milk production challenges that smallholder farmers currently face[29].

Animal breeding and health | For animal breeding, **artificial insemination** can be used as an SCP practice. It involves introducing living sperm into the reproductive tract of female cattle to speed up the reproduction process[30].

[28] Kyule, et al 2020. Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

[29] Kwamboka, E., Nyambane, A., Ogeya, M., Takama, T., & Diaz-Chavez, R. A. (2022). Transforming Kenya's dairy industry through sustainable consumption and production practices.

[30] Kwamboka, E., Nyambane, A., Ogeya, M., Takama, T., & Diaz-Chavez, R. A. (2022). Transforming Kenya's dairy industry through sustainable consumption and production practices.

Interviews with farmers in the LVB region however showed that the adoption of AI is still low with most of them using bulls.

The current practices in the region provide significant opportunities for introduction of practices that would curb GHG emissions. Various practices have been introduced in the LVB region as shown in the table below:

Table 1: Practices reported in LVB Counties

VALUE CHAIN STEP	Climate Smart Practices
Input supply and production	Feeds and feeding was mentioned as one of the major challenges facing dairy farmers in the LVB counties. Adoption of new high value fodder varieties such as Bracharia, fodder sorghum, millet maize, super nappier (Pakchong grass), sweet potato vines, lucerne, desmodium calliandria, sesbania and luceana among others. Introduction of intensive production systems through zero grazing. Lelchego, one of the farmer cooperatives visited reported that there is increased adoption of Zero grazing estimating and adoption rate of 30% of their farmers in the last 2 years. Introduction of Artificial Insemination for breed improvement. Adoption is still low with most farmers using bulls. In Lelchego however, through support of development partners such as Heifer, farmers are adopting more efficient breeds suited to their ecological zones and farmers capacity to provide adequate feeds for their animals. Farmers reported a move towards adoption of Ayshires and Jerseys that require less feed input than Friesians that were previously preferred by farmers due to their high milk potential. Farmers are being trained on ration formulation using locally available forages and crop residues. NCBA CLUSA, a development partner is providing training on biogas installation for farmers in Lelchego cooperative. Adoption is still low with only 20 farmers out of the 2,500 active members has installed a biogas unit. The challenge is the cost of installation which is high for many farmers. To accelerate adoption, Lelchego through the farmers SACCO is planning a biogas product with flexible payment and interest for farmer for its members. VI agroforestry supporting 84 farmer groups in Transnzoia County has been training farmers on intensive production systems, composting, hay and silage making.
Harvesting, storage, and processing	Solar cooling and water heating technologies. For example, Ainabkoi farmers' cooperative in Nandi has partnered with processor (NKCC) and solar company to install solar technology for milk cooling. The processor deducts Kes 3 for every litre of milk and pays the solar company. Lelchego dairy has visited Ainabkoi and seeks to adopt their model. Currently Lelchego has 6 coolers with a capacity of 20,000 litres (currently collecting 10,000 litres therefore utilizing only 50% of the capacity). All the 6 coolers are run on electric power. Lelchego dairy has partnered with Sun culture, to provide solar appliances including radios and lighting for their members on credit.
Markets	Most of the milk in the LVB counties is sold in raw form to processors who include New KCC, Brookside and highlands dairy among others. Milk is also sold to informal sector traders who sell in the urban centres.

Source[31]

2.1.2 Milk Production

The Milk production is dominated by small holder farmers estimated to be more than 1 million. In general, smallholders each have 3 to 5 acres (1.2 to 2.0 ha) of land although some have slightly more than 20 acres (8 ha) and others less than 0.5 acre (0.2 ha) and about two to five head of cattle yielding about 5 kg of milk per cow per day. Milk sales are low, at less than 10 kg per day. Small holder farmers contribute more than 70 percent of gross marketed production from farms[32].

The average productivity per cow in Kenya is estimated to be 7-8 litres per day. The average production per lactation is between 2,000 litres and 2,400 litres. These figures are low compared to the leading global productivity of 18,000 litres per lactation. Interviews with farmers and government officers in the LVB region reported that productivity stands at 3-4 litres per cow per day which is even lower than the national average. The low productivity

[31] Interview with value chain actors in Nandi and Transzoia Counties

[32] FAO, 2011 Dairy Development in Kenya

is attributed to inadequate feeding, inadequate and inefficient breeding services, inefficient dairy research, poor animal husbandry, inadequate extension and advisory services, low quality feeds, environmental, socio-economic/cultural factors, ineffective disease control and veterinary services, poor infrastructure, high-cost inputs and/or labor among others. Poor access to output markets also contributes to low incentive in increased dairy production[33].(Sessional paper no 5)

Of the milk produced, about 42% is consumed on-farm by calves and household members. An estimated 58% of milk produced is marketed. Over 70% of marketed milk is sold through the informal sector in Kenya[34]. The rest is marketed through 34 milk processors and 68 mini dairies registered by Kenya dairy board. In 2021, data from KDB shows milk processors handled over 800 million litres of milk.

2.1.3 Chilling, bulking and transportation.

Milk bulking centers have emerged as important business hubs for producers, minimizing the cost of collecting milk from small, scattered producers by the major processing firms[35]. While there are an estimated 200 chilling plants in the country, poor management and a lack of proper operations systems lead to prohibitive start-up costs and massive losses. This provides an intervention opportunity to strengthen the governance and managerial capabilities of cooling plant operators and foster public-private partnerships to establish more centers.

2.1.4 Processing and packaging

There are 92 dairy processors in the country, about 35 of which are large-scale companies producing a wide range of dairy products. Besides the processors, there are 128 registered mini-dairies and 173 cottage processors. Since the bulk of milk produced is channeled through the 'warm chain' and Kenyan consumers predominantly prefer unprocessed milk, most processing companies are operating well below capacity with volumes dictated largely by fluctuations in demand for processed milk. Expanding markets for processed dairy products both domestically and for export is critical to increasing the utilization rate of existing processing infrastructure[36].

2.1.5 Distribution, wholesaling, and retailing

The concept of milk dispensing has emerged as a popular alternative source of milk, providing low-income consumers with quality milk at affordable prices. However, its penetration is still limited, and the safety of dispensed milk requires greater attention. Dispensers present significant opportunities to develop the dairy value chain but require interventions to identify safety issues and facilitate investments in more dispensing units, especially in small urban areas and urban lower income classes. This will ensure consumers get a fair price, as well as guaranteeing producers better markets.

2.1.6 Consumption

Kenya's per capita milk consumption of 110 litres per year is the highest in Sub-Saharan Africa and it is expected to rise to 130 litres per year by 203037. However, this is still below the recommended per capita consumption of 220 litres and there are still huge discrepancies in milk consumption between rural and urban populations. This is also reflected in different income groups. Studies have indicated that per capita milk consumption in Kenya is typically 45-49 percent higher for urban consumers' vis-à-vis rural consumers. Milk consumption appears to be

[33] Sessional paper no. 5 of 2013 on the national dairy development policy

[34] Wilkes A, Odhong' C, Ndonga S, Sing'ora B, Kenyanito L. 2018. Access to and supply of finance for enhancing dairy productivity. CCAFS Working Paper no. 232. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

[35] Nyokabi, S. N., de Boer, I. J., Luning, P. A., Korir, L., Lindahl, J., Bett, B., & Oosting, S. J. (2021). Milk quality along dairy farming systems and associated value chains in Kenya: An analysis of composition, contamination and adulteration. *Food Control*, *119*, 107482.

[36] Berut, Z. J. (2020). *Influence of Supply Chain Collaboration on Performance of Dairy Processing Firms in Kenya* (Doctoral dissertation, JKUAT-COHRED).

[37] KDB, 2021 Report on a Study on Cost of Milk Production In Kenya

highly income elastic and can be expected to rise with growth in income per capita, population, industrialization, and urbanization.[38]

2.2 End-market Analysis

2.2.1 Demand

Almost all Kenyan production goes to satisfy local demand. Kenya has about 34 active milk processors. Although the market for processed milk and milk products grew strongly over the past 10 years, approximately 70-80% of the milk is distributed to the consumer through the raw milk market[39].

Export Trade in dairy products is insignificant. Net imports represent only about 0.5% of total milk produced in Kenya. Milk powder makes about 70% of imports by value and is mostly used by Kenyan dairy processors during dry season to constitute fresh milk. New KCC and Brookside are the only processors in Kenya with the capacity to process milk into powder[40].

Currently, the annual milk production is about 5.2 billion litres with the bulk being cow milk (3.9 billion litres) and this is projected to grow to about 12.6 billion liters by 2030[41]. It has been reported the current year (2022), the country is facing a deficit of between 1.275 and 3.53 billion litres of milk per year. The per capita consumption of milk and dairy products is also projected to double by the year 2030, fueled urbanization, increasing per capita consumption and high population growth[42]

Export opportunities are mainly in the Eastern and Southern African region. In 2014, exported milk and dairy products were worth KES 1 billion[43]

Due to increased demand in Kenya and relatively low production costs in Uganda, Kenya is currently a net importer of milk. Production of value-added products such as milk powder, ghee, yoghurts and cheese are growing, but overall, still low. Enforcement of quality standards is insufficient. From an import–export perspective, these are important weaknesses.

A regional market for Kenyan dairy products is widely available because of free movement of dairy products within the East African Community (EAC) and tripartite regional arrangements involving EAC, Common Market for Eastern and Southern Africa (COMESA) and Southern African Development Community (SADC) facilitating regional trade. In the broader African region, demand for milk is expected to increase across the board following increasing populations, urbanization, and rising incomes

The rising demand presents several opportunities for sector-wide and project specific interventions. Unfortunately, production remains non-commercialized, heavily rain-dependent, and the market is still highly informal. The informality of the market sector is, therefore, holding back investment in processed dairy products. The situation is exacerbated by climate change that has seen the country experience frequent droughts.

[38] Sessional paper no. 5 of 2013 on the national dairy development policy

[39] Ettema, F, 2015. Dairy Development in Kenya

[40] Auma, J., Kidoido, M. and Rao, J. 2017. Feed the Future Accelerated Value Chain Development (AVCD) Program: Dairy component value chain analysis. Nairobi, Kenya: International Livestock Research Institute (ILRI).

[41] Ingasia, et al 2020, Milk Vending Machines in Kenya's Retail Market: Trends and scenario analysis

[42] Rademaker, I.F., R.K. Koech, A. Jansen, and J. Lee, 2016. Smallholder Dairy Value Chain Interventions. The Kenya Market-led Dairy Programme (KMDP) status report. Wageningen UR Centre for Development Innovation. https://library.wur.nl/WebQuery/wurpubs/fulltext/395978

[43] KDB 2015

2.2.2 Market structure

The unreliability of data makes it difficult to draw concrete conclusions about the milk marketing patterns. The three largest processors, New KCC, Brookside and Githunguri dairy, controlled about 85% of the market in 2015. However, other processors such as Meru Dairy Cooperative Union have seen a lot of growth in the last 10 years and control a significant share of the market. In addition, Brookside dislodged new KCC as the market leader, controlling 36% compared to New KCC's 34%.

Kenya is mainly a liquid milk market with growing demand for yoghurt, cheese, and butter. Milk and milk products are largely locally consumed, with some processors exporting minimal quantities to 9 African countries that includes: -Uganda, Tanzania, Rwanda, Burundi, Southern Sudan, and UAE-Ghee.

In the LVB region, most milk is sold raw. The main buyers are New KCC, Highland Dairy, Daima, and Brookside. In Nandi County 17 Cooperatives have come together to form Nandi Union. However, only 8 cooperatives are active with Lelchego being one. The Union invites buyers to tender for their milk every 3 months. The 8 active cooperatives are supplying 20,000 litres of milk per day through the union. The price at the time of the visit was Ksh. 41 per litre of milk.

2.2.3 Drivers

Key drivers

Development of the dairy industry in Kenya (past and present) has been driven by the following factors among others: Promotion of smallholder farming (Government initiated land subdivision and settlement schemes after independence), School milk Programme (especially Nyayo school milk Programme, 1980 to 1998), Organization of dairy farmers into cooperatives and other forms of producer groups, Subsidized agriculture up to 1987 with dairy farmers benefiting from subsidies in breeding, animal health, and extension and training services, Favorable Government policies such as abolishment of milk quotas in 1965 and ongoing distribution of milk coolers to organized groups and, Interest and investment in the dairy sector by development partners and private sector[44].

Animal health

Animal health affects both productivity of milking heads and the quality of milk. Responsibility for animal health is shared between the national and county governments. Both have been working to enhance disease monitoring and surveillance by launching vaccination campaigns, especially in the open grazing areas. Regulation of veterinary service providers remains critical, especially as it pertains to safety.

Issues such as microbial resistance in both humans and animals has been linked to misuse of medicines. The government has a policy to address this. However, stringent implementation of measures on animal health and food safety is required.

Marketing

The marketing of milk and dairy products remains a key talking point for the industry. The informal market dominates the raw milk segment. This is because there are many smallholder producers who are not organized in groups or cooperatives.

The informal market, however, offers a higher return to producers. A key criticism is that the milk is unsafe due to poor handling or adulteration. Defining and enforcing food safety standards for milk value chain can improve safety. The standards should define how milk is handled, transported, and packaged. Awareness among actors and consumers in the informal market could have greater results in ensuring the safety of milk to consumers.

[44] Board, K. D. (2019, August). Kenya Dairy Industry: Status and Outlook. In *15th ESADA dairy conference and exhibition Kenyatta international conference centre, Nairobi*.

Government policy encourages value addition and processing by cooperatives, but progress has been slow because of market concentration at processing. The largest processor controls more than a third of the market, and two processors control two-thirds of the market. The regulator should regularly monitor changes in market structure to ensure farmers receive competitive prices.

To support cooperatives in value addition, both the national and county governments have distributed milk coolers to cooperatives. However, most of these remain collection centers for processors, and few have engaged in processing. Besides, milk imports and dairy products from neighboring countries such as Uganda, are favored by consumers because of lower prices.

Capital

Other key challenges affecting the sector include access to capital for both farmers and value chain actors. This prevents critical investments in the industry. Furthermore, supply of public goods such as improved rural roads adversely affects the collection and delivery of milk, especially during the rainy seasons.

To revitalize the dairy industry, improving coordination across the government and stakeholders in the industry is a first step. Next, the government must address the policy incoherence in the industry.

2.3 Analysis of Value Chain Elements -Value Chain Nodes, Actors & Activities

The key value chain nodes are input supply, production, transportation and aggregation, processing, retail, and consumption.

Farmers' access to productivity enhancing technologies and services remains poor. Breeding services include access to semen through bulls or artificial insemination (AI). Although AI use is predicted to continue growing among dairy farmers, its use remains inaccessible to smallholder farmers[45] One of the challenges facing the dairy sector is the supply of quality inputs and services. Dairy feeding constitutes a major cost component of dairy production accounting for between 70-80% of total cost
of production[46].

In Kenya, milk is produced from cows, camels, sheep, and dairy goats estimated at 5.2 billion litres annually. Of this total, cow milk accounts for the largest share (75%). Milk is primarily produced by an estimated 1.8 million smallholder dairy farmers under three main productions systems - zero grazing, semi-zero grazing and open grazing. Domestic and regional demand for milk is growing mainly due to population growth, increasing urbanization and rising incomes[47].

Kenya dairy board reports that there are over 500 coolers installed with capacity to cool over 4M litres of milk per day.[48] The coolers are owned by processors and dairy cooperatives. There are over 600 dairy cooperatives according to KNBS statistics of 2018.

[45] Auma, J., Kidoido, M. and Rao, J. 2017. Feed the Future Accelerated Value Chain Development (AVCD) Program: Dairy component value chain analysis. Nairobi, Kenya: International Livestock Research Institute (ILRI).

[46] Auma, J., Kidoido, M. and Rao, J. 2017. Feed the Future Accelerated Value Chain Development (AVCD) Program: Dairy component value chain analysis. Nairobi, Kenya: International Livestock Research Institute (ILRI).

[47] Report on a Study on Cost of Milk Production In Kenya, Tegemeo Insitute,2021

[48] Kenya Dairy Board, 2018

The informal sector is reported to control 70% of the marketed milk. It is made of itinerant traders who buy milk from the rural producing households and then transport milk in raw form for sale in urban and peri-urban centers where most consumers are located[49].

The formal sector is made up of licensed operators who include more than 34 processors and 68 cottage industries[50]. The formal channel has a processing capacity of 3.75M. only 46% of this capacity is utilized[51]

Most of the processed milk is sold through kiosks and supermarkets. An emerging market is the ATM (Milk dispensers) market. Based on trends since 2005, the ATM milk market segment would grow threefold in ten years (from the current 102,204 tonnes to 343,307 tonnes). In the best case, the ATM market segment has potential to grow by more than four times (438%) whereas in the worst case it would double (213%) in ten years[52].

At approximately 110 litres, Kenya's per capita milk consumption is five times higher than the average of other sub-Saharan African countries[53]

2.3.1 Value Chain Actors

The industry supports a range of actors, including farmers, milk traders, processors, consumers, and several service providers. It is regarded as a successful and vibrant industry due to the growing domestic milk production, processing capacity, per capita milk consumption and export potential

The dairy value chain is relatively short (i.e. has relatively few intermediaries between farmer and consumer) due to the perishable nature of milk. Traders (formal and informal), dairy producer cooperatives, milk bulking/cooling centers and transporters are the main market intermediaries.

[49] Nasiuma et al 2014. Milk Production and Marketing Preliminary Survey 2013

[50] Nasiuma et al 2014. Milk Production and Marketing Preliminary Survey 2013

[51] Ibid

[52] Ingasia, et al 2020, Milk Vending Machines in Kenya's Retail Market: Trends and scenario analysis

[53] Rademaker, I.F., R.K. Koech, A. Jansen, and J. Lee, 2016. Smallholder Dairy Value Chain Interventions. The Kenya Market-led Dairy Programme (KMDP) status report. Wageningen UR Centre for Development Innovation. https://library.wur.nl/WebQuery/wurpubs/fulltext/395978

2.3.1.1 Production, collection/aggregation, processing, wholesaling, and retailing

Production

In Kenya, milk is produced from cows, camels, sheep and dairy goats estimated at 5.2 billion litres annually. Of this total, cow milk accounts for the largest share (75%). Domestic and regional demand for milk is growing mainly due to population growth, increasing urbanization and rising incomes[54].

Milk is primarily produced by an estimated 1.8 million smallholder dairy farmers under three main productions systems - zero grazing, semi-zero grazing and open grazing. Small holder farmers produce about 80% of the milk while about 2000 Medium and large-scale farmers who produce about 20% of milk in Kenya[55].

Productivity per cow per day remains low at 7-9 litres per day mainly due to poor feeding, among other poor animal husbandry practices. Even where smallholders raise cows of improved breed (e.g. Friesians, Aryshires and Jerseys), the genetic potential of these animals is often much higher than is reflected in current milk yields. Potential reasons include poor management of the cow's lactation cycle, poor feeding (in terms of quality of forages and quantity) and poor cow welfare.

Without factoring in fixed and opportunity costs, average cost of milk production was KES 13.02 per litre and ranged from KES 10.57 to 17.81 per litre. The open grazing system had the lowest costs (KES 10.57), which is mainly due to the relatively lower costs for feed concentrates. Zero grazing system had the highest cost (KES 17.81), which is about 68% higher than in the open grazing system. The average gross margin (GM) per litre of milk produced was KES 21.69[56].

In all the three production systems, variable costs constitute the largest proportion of production costs and, therefore, managing yield remains the most important driver of profits. Active management of production costs and reducing seasonality of feed availability are key strategies to achieving greater yield management in commercial dairy production[57].

The sector has been growing at an estimated rate of between 3–4% annually. The contribution of cattle milk has been growing with increased total national milk production. Reliable statistics estimate that the country has close to 6.8 million dairy cattle, of which 3.2 million are lactating annually[58].

Counties in the LVB region have largely been considered non-tradition dairy production areas. However, through programs such as Feed the Future, USAID KAVES and World Bank and KCSAP, the regions have adopted dairy production.

Dairy production is greatly hampered by climate change in the LVB region. Firstly, temporal, and spatial variability in rainfall have resulted in a decrease in agricultural productivity in the LVB[59]. This decrease in productivity is widespread as rain-fed agriculture is practiced by 60% of the population in the LVB and contributes ~34% to the national GDP[60]

[54] Report on a Study on Cost Of Milk Production In Kenya, Tegemeo Insitute,2021
[55] SNV, 2013 Study in the Kenyan Animal Feed and Fodder Subsectors
[56] Tegemeo Institute. Report an a Study On Cost Of Milk Production In Kenya, 2021
[57] Ibid
[58] Auma, J., Kidoido, M. and Rao, J. 2017. Feed the Future Accelerated Value Chain Development (AVCD) Program: Dairy component value chain analysis. Nairobi, Kenya: International Livestock Research Institute (ILRI).
[59] East African Sustainability Watch Network 2014. Lake Victoria climate change readiness brief, No.3.
[60] Ibid

However, there is great potential to improve productivity by improving pastoral livestock keeping practices, such as the use of improved breeds and feeding regimes. CSA is gaining momentum in Kenya. This is attributed to the fact that agriculture is recognized as a sector with great potential for contributing to the achievement of a range of development goals related to food security, nutrition, poverty reduction, and climate change adaptation and mitigation. Apart from traditional agricultural techniques, Kenyan farmers have started adopting new, improved technologies, as evident in both crop and livestock production. Some examples include biogas production using biodigesters (especially applied in intensive dairy production), and improved pastures management in agrosilvopastoral systems in the highlands and sub-humid areas, as well as in intensive and extensive dairy production[61] (mostly through grass–legume associations), among others.

Milk collection, aggregation, and chilling

Milk is collected at collection centers or farm gate by cooperatives, individual traders, or milk processors after which it is transported either to the market as raw, to a chilling plant or to the processor. Chilling and bulk cooling facilities in Kenya are either owned by cooperative societies, cooperative unions, collecting agents for processors or government-installed facilities.

Cooperative societies

The number of registered societies and unions in Kenya has almost doubled from 345 in 2012 to 623 in 2018[62]. This was accompanied by an increase in the membership numbers as shown in figure 4 below.

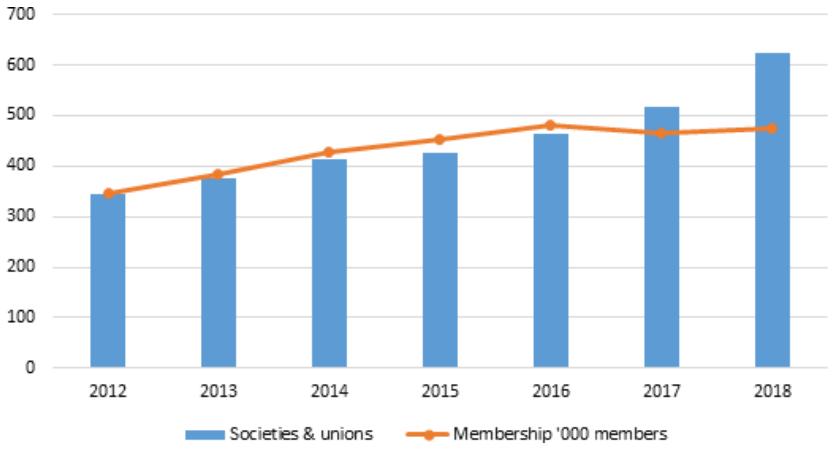


Figure 4: Cooperative societies and unions

Source: *KNBS (Various), Statistical Abstracts 2013 - 2019*

In the recent past, there have been major investments in milk bulking and cooling facilities by donor funded projects, the private sector, and by farmers' cooperatives. The bulking centers provide an important link between producers and the processors, while at the same time preserving the quality of the milk. Most of the plants are owned by producer groups and supported by international NGOs.

[61] Climate-Smart Agriculture in Kenya, World Bank, CGIAR, CCAFS, CIAT 2015

[62] Kyule, et al 2020. Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

Raw milk cooling capacity has been expanded by Government with procurement distribution of over 350 coolers. This will improve the microbiological quality of raw milk and support processing of quality milk and milk products. The investment by government brought over 500 coolers, with a capacity to cool over 3.4M litres of milk per day. some of these coolers are not operational while others are operating under capacity. Despite the supply of electricity in rural areas through the rural electricity Programme, the electricity installation and tariffs are high discouraging investments in milk cooling.

The main activities at cooperative level are milk cooling and marketing for members. Some cooperatives/unions in Kenya have set up agro-vet shops and services where members can get farm inputs on credit to be recovered from milk proceedings delivered. Others include training and cash advances for members.

Milk traders

The other key players at this node are formal and informal traders who purchase milk directly from producers or dairy cooperatives and transport it in aluminum containers and sell either directly to consumers, milk bars or milk processors. The formal traders are licensed to trade in milk by KDB and use the recommended transportation and packaging equipment. The informal traders mainly referred to as hawkers sell raw milk in the urban centers and their trade is considered illegal. However, since the passing of the new regulations by Kenya Dairy Board and continued enforcement most of the informal sector traders have either left the trade or been forced to formalize[63].

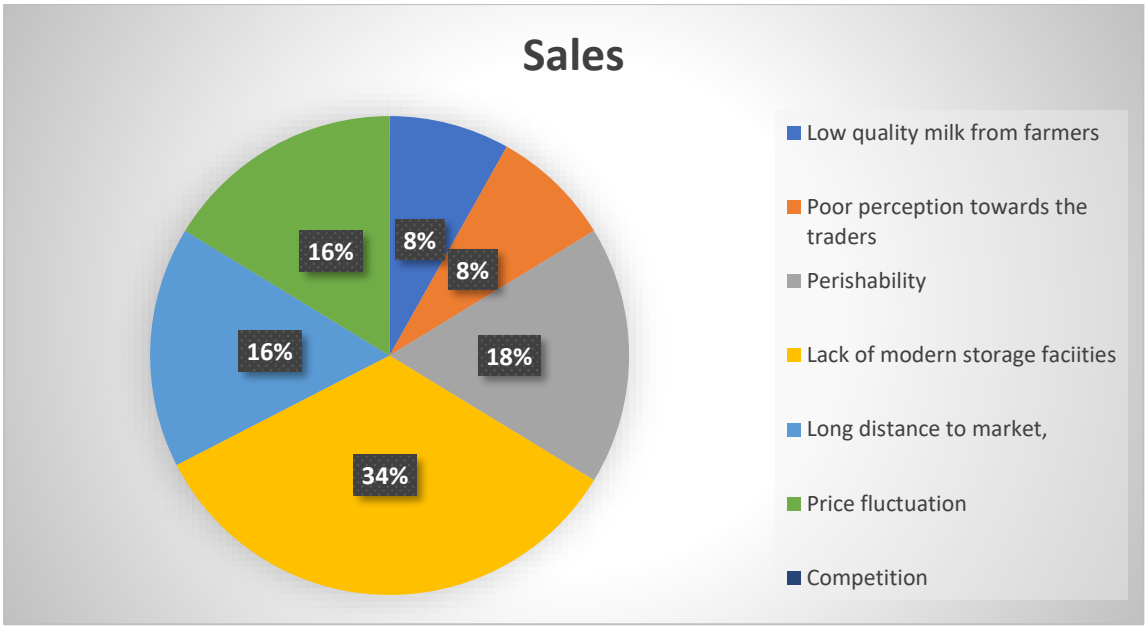


Figure 5: Informal traders challenges.

[63] Kang'ethe, E. K., Grace, D., Roesel, K., & Mutua, F. K. (2020). Food safety landscape analysis: The dairy value chain in Kenya.

Processing and Packaging

The processing sector has been relatively unstable with the entry and exit of many low-capacity processors that lack capital in addition to management incompetence. There are currently 34 registered processors and 68 cottage industries[64].

The main players are Brookside, New KCC, Meru Dairy Union and Githunguri Dairy who control over 80% of the pasteurized milk market. Most milk processors operate at half capacity and their sales account for about 12% of fresh milk sales[65].

Processed milk has continued to grow with the total milk processed in 2021 above 800 million litres and increase from 680 million litres reported in the previous year as shown in figure 5 below.

The total milk processing capacity is approximately 3.75 million litres per day; approximately 46% of this capacity was utilized in 2018[66]

Milk packaging is a critical component in milk marketing and quality control, however; the conventional milk packaging materials are costly resulting in high and unaffordable prices of packaged milk. As a result, there is a tendency to package milk in non-food grade materials that are unhygienic and environmentally unfriendly. Moreover, there has been a shift from packaged milk to unpackaged milk through emergence of milk ATMs in response to demands of low-priced milk by the low-income groups.

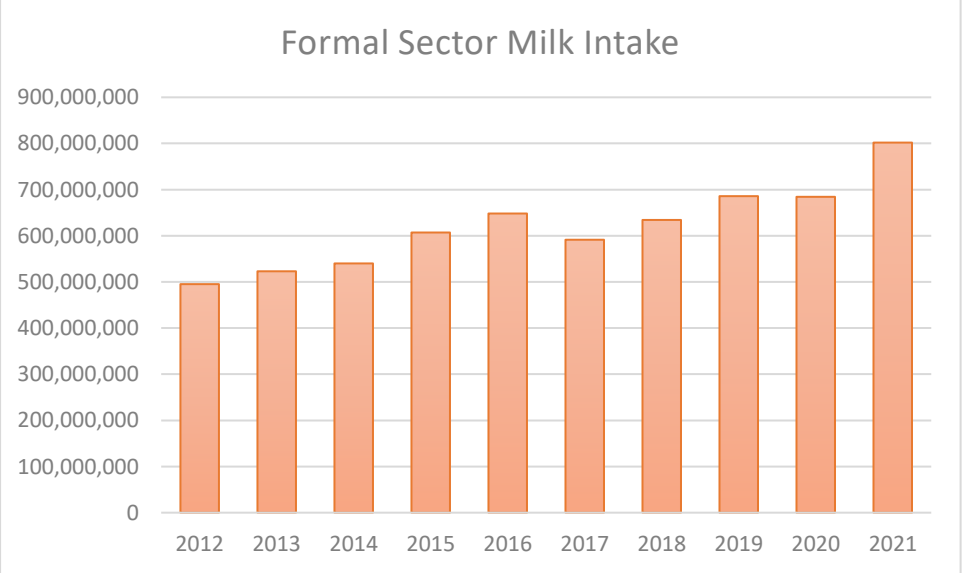


Figure 6: Formal Milk intakes (2012-2021)

Source, KDB 2022. Analysis by consultant

Of the milk processed, 85 per cent is sold as fresh milk either as short life pasteurized milk or long-life UHT milk while 3 per cent is processed to make yogurt, 7 per cent as fermented milk and 3 per cent is sold as powdered milk.The remaining 2 per cent is processed with value-added products such as cheese and butter[67].

[64] KDB, 2021
[65] Sessional paper…..
[66] Ibid
[67] KDB, 2017

Milk retail and consumption

The key players here are supermarkets, kiosks, milk bars and general shops. Total milk consumption by Kenyans is growing at 4 per cent per year (MoALF, 2019) consistent with the population growth rate. There is a huge unmet demand for milk andmilk products in Kenya, which has widened the demand-supply gap of milk and milk products. Compared to the daily demand of 8.2 million litres, the daily supply is 4.26 million liters[68]

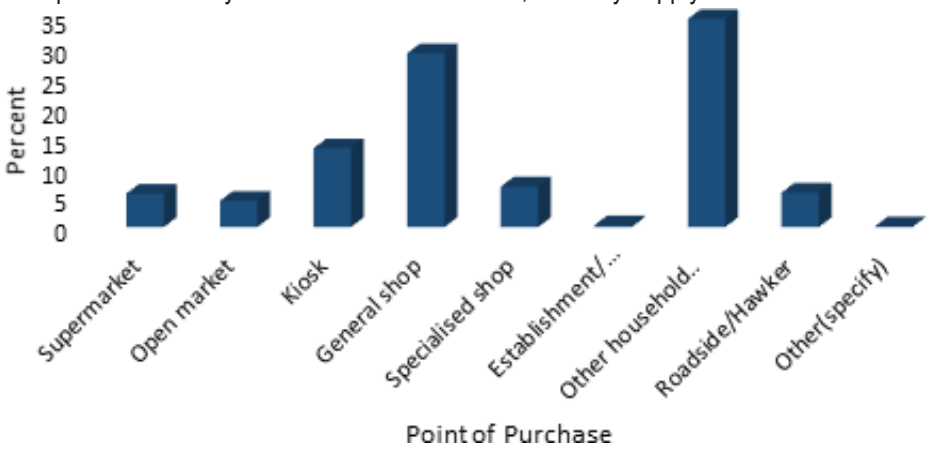


Figure 7: Points of purchase Source[69]

These main purchase points are supermarkets and kiosks. The distribution of the sales volumes is as shown in figure 7 above. The biggest volumes were sold by households, possibly from one neighbor to another while the general shop sold a substantial volume of milk. The other players in the retail sector include milk traders/hawkers and milk bars with over 1600 registered milk bars according to Kenya dairy board.

2.3.1.2 Technologies used in each node- advantages/ disadvantages

Small and medium scale dairy producers in Kenya apply different technologies to their operations. Some of the climate smart technologies discussed below.

Biogas milk chilling

Milk demand is expected to double in coming years, only 15 percent of milk produced reaches the formal market and 30–50 percent is not delivered to milk collection centers. The reason being that raw milk is not cooled at farm level because 85 percent of rural areas lacks access to a (reliable) power grid. [70]

SimGas is a design and production company with facilities in the Netherlands and East Africa that focuses on clean, affordable, and high-quality energy and sanitation solutions. Their teams work together to design, manufacture, and install high quality, modular, domestic biogas systems that can be installed in a day.

Biogas milk cooling can greatly improve the income of small dairy farmers, help supply to meet demand, help farmers to access the formal dairy market, and contribute to improved nutrition. The quantity and quality of milk will improve which will enable dairies to better meet the increasing demand for milk and milk products. Savings at the farm level will lead to additional investments and more satisfied members. In addition, the use of clean energy (biogas)for cooling and other purposes, such as cooking, will help reduce deforestation and carbon emissions.

[68] Kibogy, M 2015.Kenya Dairy Industry: Status and Outlook

[69] Kyule, et al 2020. Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

[70] https://energypedia.info/wiki/Biogas_Milk_Chilling_to_Increase_Productivity_and_Incomes_of_Dairy_Farmers

Solar-Powered Refrigeration

Due to limited electrification in rural areas, 85% of Kenya's dairy farms do not have access to refrigerated storage and transportation. This deficiency in the distribution chain results in less than half of the milk produced reaching dairy processors. Of the milk that is processed, up to 30% of it may spoil without appropriate cold-storage options. Consequently, many dairy farmers and processors unnecessarily may lose significant earning potential from their operations.

The project was implemented by SunDanzer and Winrock international, a leader in agricultural development and has more than a quarter century of experience with renewable energy based rural electrification. SunDanzer has delivered and installed nearly 70 solar milk cooling refrigerators in Kenya.

By drastically reducing milk spoiling, this sustainable energy approach seeks to raise dairy farm production and profits. Bacterial counts are reduced and milk quality for customers is improved with effective cold-chain storage.

Insulated milk cans

Small and medium sized dairy farms milk is transported to milk collection facilities, without any form of cooling and lack of hygiene and cleaning procedures. Under warm climatic conditions, milk can exceed the maximum bacterial count prescribed by food safety laws after about two to five hours. Lack of quality can cause high rates of milk rejection at collection centers or dairy plants during the hottest times of the year.

The milk cooling solution was developed by the University of Hohenheim. The milk-cans implemented are made of stainless-steel and have a capacity of 30-liter milk and 8 kg Ice. This allows flexible use of them depending on the cooling requirements.

2.4 Support services in the extended value chain

2.4.1 Suppliers of physical inputs

Feed and Fodder

Availability of quality fodder is a serious issue, particularly for resource-poor dairy farmers with little or no land for cultivation. The magnitude of this problem naturally varies from farmer to farmer, but it clearly is a sector-wide constraint. An estimated 80% of the total costs of a successful dairy enterprise are incurred in feeding and management, with feeding alone constituting on average 68%[71]. Dairy Production systems are rain-dependent with only limited awareness amongst farmers on using a proper feeding regime and low preparedness for dry periods. Thus, most farmers produce and sell below their potential.

While feeding means both forages and concentrates, experience from practicing farmers indicate that a significant proportion of nutrition is met while using appropriate quality and quantity forages, rather than the more expensive concentrates.

Yearlong feed availability in adequate quantities and at affordable prices is a major requirement in livestock production. However, feed scarcity has continued to constrain livestock production in Kenya (Ndathi et.al 2013). A study conducted the Fresian on behalf of the SNV/KMDP program noted that "milk production and productivity are highly influenced by the feeding regime and fluctuate sharply during the year depending on rainfall patterns and consequently availability of forage". This seasonal fluctuation in milk production affects both dairy farmers and processors and leads to a scenario that is not conducive for long term investments by either of them. The fodder availability situation is worsened by unpredictable weather patterns occasioned by climate change.

However, feeding of livestock continues to pose many problems due to lack of information on composition and utilization of locally available feed resources. These problems are aggravated by lack of access to and high cost

[71] SNV, 2013 Study on the Kenyan Animal Feed and Fodder Sub-sectors, Trends in the Fodder Sector

of feed inputs. The use of cheap and readily available local feed resources has great potential to increase livestock productivity[72]

Most of the fodder available in Kenya, both on-farm and on sale, provides low energy and little crude protein. The common fodders in this case include Napier grass (mostly in central Kenya and parts of eastern region) and Rhodes and other grasses for free grazing and hay making (mostly in the Rift Valley). When cows are fed on Napier grass alone and if they are under good management, the milk production during lactation is at maximum 7 kg/day and 9–12 kg/day when the cow is fed on a Napier–legume (desmodium) mixture. On grass alone (e.g., Rhodes grass or Nandi setaria), an average milk yield of 5–7 kg/day has been obtained and 7–10 kg/day on a grass–legume mixture. Oats fed to a dairy animal can lead to a production of up to 12 kg/day (6) . So, if fed on Napier grass, production would only increase by complementary feeding of other sources of protein and energy rich fodder or concentrates. Fodder trading is evident in both formal and informal segments. The formal segment is dominated by commercial fodder producers while the informal segment includes even the localized trading of fresh fodder (e.g., Napier grass) between one farmer and the other. Quality is an issue across the two segments with the informal trading most affected where farmers end up buying grasses harvested at very late stages, as well as crop residues with very low nutritional levels. Hay (Rhodes grass) and Lucerne are the most traded, with Napier dominating the localized sales between farmers within proximity. Commercial production and trading of maize silage is emerging in some parts of the country.

One of the measures that have been taken by government and development partners is the introduction of hybrid fodder varieties suited for different Agro-Ecological zones. Institutions such as CIAT, ILRI and KALRO have run trials and introduced forages to different parts of the County. In some parts of the LVB, USAIDs Feed the Future program AVCD and KCDMS has played a key role in introducing climate smart practices and forage production and conservation strategies to small holder farmers.

KALRO with funding from the Irish Embassy's IKAFS has been undertaking trials for a forage-based dairy production system in Kenya. The initiative is also developing an economic breeding index (EBI) that would integrate a knowledge institution to pioneer the practice of matching the genotype with the environment.

The dairy producing areas in Kenya have a wide variety of natural pastures and forages of varying quality. In addition, farmers also produce large quantities of crop residues that are used for livestock feed. If properly managed, the natural pastures, forages and crop residues can provide feed materials for yearlong livestock feeding to provide the required ruminant nutrition for the livestock. However, feed material available is being wasted because of poor feed management and utilization strategies. This would be a key area of focus to enable farmers utilize feed material on their farms through providing skills and knowledge on ration formulation.

The fodder varieties introduced are those with robust adaptability to different agro-ecological zones. This is an important attribute in responding to increasing risks of changing and variable climate, which is a reality today. The varieties would ordinarily have quality attributes relevant to reducing enteric methane emissions, which contribute to mitigating climate change. High yielding and high protein fodder also address the nutritional limitation in increasing milk productivity and reduced the need for high-cost concentrate use. This reduces the cost of production while supporting increased milk yields thus enabling farmers to earn improved returns.

Dairy farmers grapple with low quality and high cost of feeds. Studies show that improving the quality of fodder significantly improves milk productivity.

[72] Lukuyu, Et al, 2011 Livestock feed resources: Current production and management practices in central and Northern rift valley provinces of Kenya

Fodder varies in quality based on nutrients. High quality fodder is grown. Fodder yield depends on seed quality and farm level agronomic practices. Furthermore, a farmer must have know-how on mixing different types of fodder to attain the nutrition level required by the animal. Therefore, improving farmers' knowledge is critical.

Rising costs of commercial feeds drive the cost of production up. Feed prices have continued to rise even after government waived the duty on imported raw materials.

Breeding

The choice of breed should be informed by production system, ability, experience or expertise of the farmer, and environmental factors such as climate. Artificial Insemination is the most preferred method to improve animal breeds. The artificial insemination was previously offered by the government, but the service was privatized in the late 1980s as part of Kenya's Structural Adjustment Programs. This was meant to improve the reach to farmers by private service providers.

The national dairy breeding policy is being implemented through the National Dairy Cattle Breeding Program. This program is the only major livestock improvement Programme that has been under implementation in the country. The aim of this program is to improve the dairy breeds for enhanced productivity. The program involves progeny testing programmes, contract mating scheme, dairy recording services for milk and the artificial insemination (AI) services.

Both public and private institutions play a key role in the sector. The key government institutions are Kenya Livestock Breeders Organization (KLBO), Livestock Recording Centre (LRC) and Kenya Animal Genetics Resource Centre (KAGRC).

The Kenya government through the Department of Livestock Production (now Ministry of Livestock) has previously made deliberate efforts to improve local dairy breeds by enhancing farmer accessibility to breeding services through subsidized AI services. However, the structural adjustment programs initiated in the early 1990s forced the government to liberalize AI services and allowed several players into the sector. These changes had varying implications on smallholder dairy farming, particularly on access to breeding services. The expectations that the private sector would fill the gap left by the government and provide affordable services to the farmers were not fully realized[73]

Other that KAGRC which is the governments genetic resource centre that produces semen for sale to farmers through the private sector, genetics is Kenya is mainly private sector driven. Several companies import semen while the AI service is provided mainly by private AI providers.

Often, the breeding goals of local dairy farmers and the breeding organizations that control semen supply are not always well aligned, ultimately affecting the rate of genetic progress in semen importing countries. At the farm level, farmers face challenges of missed cycles due to lack of knowledge and skills on cycling and heat detection, unethical practices by inseminators and wrong choice of breeds among others. This has led to high cost of obtaining AI services with some farmers resulting to use of bulls.

Improving regulation and supervision of insemination and enhancing the supply of supporting infrastructure such as semen storage, will improve the genetic composition of dairy animals.

[73] Murage, .and Evans,I 2011Factors that determine use of breeding services by smallholder dairy farmers in Central Kenya

Extension services

Animal husbandry plays a critical factor in improving productivity. This is directly affected by farmers' access to extension services. Farmers in high potential dairy production areas have formed cooperatives. These provide training and extension services in some areas following the collapse of government services.

Development partners and civil society organizations have further strengthened the role of cooperatives in delivering knowledge and technologies to farmers.

Cooperatives have suffered from governance problems, causing exit of members. The Ministry of agriculture in December 2021, reviewed the Cooperative Act in a bid to tighten the policy framework. But stricter supervision and punishment for those abusing position of trust, can improve appeal of the societies.

The bulk of extension services costs are spent on staff remuneration leaving a small proportion for facilitation and infrastructure development. The staff to farmer ratio (1:5000) is also very low. This inequitable resource allocation affects basic extension services such as travel, transport, communication, demonstrations, tools to seek new information and/or adopt new technologies from research. The result has been limited follow-up of extension and advisory services leading to low adoption of new dairy technologies and productivity. In addition to the extension services provided for by the government, there are other extension service providers mainly from the research institutions, universities, development partners, NGOs, private companies among others[74].

2.4.2 Support services provided to actors along the VC

Access to finance

One key challenge affecting the sector includes access to finance for both farmers and value chain actors. This prevents critical investments in industry. Studies indicate that the smallholder dairy sector depends on finance and lending facilities in funding different production and marketing components. However, despite there being a variety of formal and informal credit services and providers, the accessibility of the dairy farmers to financial services remains poor. This emanates from the unwillingness of the financial services providers due to the high risk borne by the smallholder dairy producers[75].

Rural households selling milk are also more likely to save with a savings and credit cooperative (SACCO) or accumulating savings and credit association (ASCA) than rural households in general. In terms of loan products, 77% of rural households selling milk have never had a loan product from a formal institution (i.e., bank, Mshwari, SAC-CO, micro-finance, or government fund), similar to the 79% of all rural households[76].

A study conducted in Kinangop, one of the key dairies producing areas in Kenya showed that dairy farming had a positive coefficient which was significantly related to credit access at 90% confidence interval an indication that engaging in dairy farming as a primary occupation enhances access to credit. Hence farmers who primarily engaged in dairy farming were 8.06 times more likely to obtain credit than farmers who were in formal

[74] Sessional paper no. 5 of 2013 on the national dairy development policy

[75] Otieno, GO, Gicheha, M. 2021 A Holistic Review of the Kenyan Dairy Sector: Evidence for Transformative Interventions

[76] Wilkes A, Odhong' C, Ndonga S, Sing'ora B, Kenyanito L. 2018. Access to and supply of finance for enhancing dairy productivity. CCAFS Working Paper no. 232. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

employment[77]. The same study however showed that, 65.65% of the 230 respondents never obtained credit. The respondents cited that inadequate collateral, limited information on different credit products offered by credit service providers, inadequate guarantor ship and lack of interest were the main factors that constrained their ability to access credit. The credit sources were listed as dairy cooperatives at 10.87%. commercial banks at 4.78%, 2.17% from NGOs and 3.04% from government. Others include 4.78% from SHGs, 0.43% from professional money lenders, 2.17% from friends and relatives, 0.43% from other SACCOs and 5.65% from mobile money platforms[78].

Much emphasis in the literature is on the provision of credit to dairy farmers, while other DVC actors remain out of sight, except for milk transporters who can easily obtain loans for motorcycles. Kenyan farmers can access credit to invest in their farming business in roughly five ways: a) microcredit and saving within cooperative groups (SACCOs); b) microcredit from microfinance institutions (MFIs); c) loans from commercial banks; d) loans from government-affiliated funds; and e) credit from DVC partners[79].

The dairy value chain has credit arrangement supported by buyers; where large-scale processors fund dairy facilities, feed manufacturers, and veterinary drugs and services. Dealers of input providers advance the credit to their agents and retailers in form of goods and services. Dairy cooperative societies give credit (financial, services and products) to their members and recover the money from their deliveries of milk through a check-off system. Study findings indicate that Kenya Commercial Bank, Barclays Banks, Kenya Women Finance Trust-KWFT, Faulu, Rafiki, and Juhudi Kilimo are among the commercial banks/institutions providing formal loan products to dairy producers. Micro financial institutions and government financial institutions also provide credit to dairy farmers. Among them are Agricultural Finance Corporation (AFC), Agricultural Development Cooperation (ADC), Uwezo Funds, Youth Enterprise Fund, and NGO funds (e.g. One-Acre fund)80.

The main barriers to lending include lack of leverage and the risk of losing property in case of a default, high interest rates, complex and complicated documentation process, short-term nature of credit demanded by financial institutions and insufficient information about institutions and credit products[81]. For commercial banks, dairy businesses represent relatively high risk due, for example, to dependence on variable weather, unclear markets, and financial illiteracy of many dairy farmers and that they lack formal collateral because of the inadequate property registration system. Insufficient financial resources result to inadequate use of technology and poor dairy infrastructure.

Various strategies have been used to improve access to credit including willingness to allow assets, to be procured to function as collateral, collateral guaranteeing by development partners e.g., USAID's Development Credit Authority, combining credit and insurance to reduce risk, value chain financing where different actors such as farmer cooperatives through advances and check off systems, input suppliers and processors provide credit to members. Microfinance institutions and government affiliated funds for examples Agriculture Finance Corporation, Youth Enterprise Development Fund, Women Enterprise Fund among others[82].

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[77] Wadeya, et al 2020 Determinants of Credit Access Among Smallholder Dairy Farmers In Kinangop Sub-County, Kenya

[78] Ibid

[79] Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979

[80] Otieno, GO, Gicheha, M. 2021 A Holistic Review of the Kenyan Dairy Sector: Evidence for Transformative Interventions

[81] Ibid

[82] Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979.

High risks connected to drought, floods and the inability of small-scale farmers to provide collateral for their loans have resulted in farmers getting the lowest levels of credit compared to other sectors in the economy. There are several Micro-finance Institutions and SACCOs, banks, and insurance companies providing various support services to dairy farmers and other value chain actors. Farmers, however, are often not aware of the agricultural loans available to them.

Technical Extension and advisory services

One of the main proposed approaches to reducing GHG emissions from the dairy sector is to increase the productivity of dairy cows and lower the intensity of GHG emissions (kg CO2e per kg milk). Increasing productivity on smallholder farms will require improved access to technical extension and advisory services, improved market linkages through dairy cooperatives, and finance for investments by farmers and dairy cooperatives.

Improving on-farm management practices to increase resource use efficiency and productivity can bring benefits for farmers' incomes, resilience, and food security, while reducing GHG emissions from agricultural activities. Extension services (advisory and other technical services) play an important role in providing farmers with access to information on production practices, technologies, inputs, and markets. Extension service provision is therefore a key mechanism to promote up-scaled adoption of climate smart agriculture practices[83].

Until the implementation of structural adjustment programs in the 1980s, the government dominated provision of extension services in Kenya, after which direct delivery by government declined. Subsequent policies recognized the need to diversify and decentralize the provision of extension services.

The decline of government led extension and development of policies advocating for privatization of has given rise to innovations in delivery of extension services. Most of these models are private sector led complemented by government and development partners. Providers in the dairy sector include dairy cooperatives and processors. The study by Odhong et al gave the following recommendations to help process expand their extension models.

1. Piloting new extension mechanisms: Several processors have only recently engaged in extension service delivery and are still trying to identify effective delivery models. For example, uptake of silage making services fully funded by one processor has been good, and it is now interested to explore phasing in fee-for-service provision. Another processor is interested to explore contracting of extension services to third party providers on results-based contracts.
2. Developing sustainable financing mechanisms for extension systems: Several processors are interested in the financing mechanism being piloted by New KCC whereby extension is funded from a fixed contribution per litre of milk procured. The appeal of this system is that extension budgets can be linked to performance, and extension budgets can be ring fenced from the overall budget of the processing enterprise.
3. Assistance in developing farmer monitoring systems: Information on farmers' practices and the performance of their dairy enterprises can improve farm-specific diagnosis of constraints and opportunities for improvement and provide feedback on extension system performance. Most processors only have rudimentary documentation systems at present but are interested to integrate improved systems into their extension activities.
4. Developing gender-inclusive extension methods and extension modules addressing manure management and animal welfare: Women play key roles in dairy production and marketing. However,

[83] Charles Odhong', Andreas Wilkes and Suzanne van Dijk , 2018 Private-sector led extension in Kenya's dairy sector

women often do not have equitable opportunities to benefit from technology, extension, and marketing opportunities. Extension, animal health services and training may target men, even when the contents are relevant to women's roles on the far.

2.5 Societal enabling environment.

2.5.1 Societal environment

Which institutions set the "rules of the game" e.g. ministries, RECs, policies, standards, fees and levies? and may include - ministries, RECs, policies, standards, fees, and levies? *(tabulation)*

Policy and Regulatory Framework

Two overarching policy documents set a vision for the growth of the Kenyan dairy sector: The National Livestock Policy and the Kenya National Dairy Master Plan, and both are anchored on the Agricultural Sector Development Strategy and Vision 2030. The strategic vision of the Kenyan National Dairy Master Plan is "to transform milk production and trade into an innovative, commercially oriented and globally competitive dairy value chain by 2030". There are four strategic action plans for realizing this and their focus is increasing productivity and competitiveness; efficient delivery of demand-driven services by public and private sectors; formulating beneficial working policy and regulations, infrastructure, and enforcement; and mainstreaming cross-cutting issues into dairy value chain development.[84] The table 4 below outlines the key laws and regulations governing the sector.

Table 3: Regulatory Framework Source[85]

Value chain element	Policy Framework	Legislative Framework	Responsible organization	Aim
Entire Value Chain	Kenya Vision 2030 Agricultural Sector Development Strategy (2010-2020) National Livestock Policy (2008, 2013,2019). Kenya National Dairy Master Plan (2019)	Dairy Industry Act (1984/2012)	KDB	Regulation, development and promotion of dairy sector
Input (FeedSupply)		Standards Act(1981 / 2012)	KEBS	Setting and controlling standards or codes of practice for commodities produced or imported into Kenya
Input (FeedSupply)		Fertilizers and Animal Foodstuffs Act(1985 / 2012) Standards ActCap 496 Animal Feedstuff Bill (Currently Under review)	State Departmentof Livestock(Veterinary Services)	Regulation of the importation, manufacture and sale of agricultural fertilizers, animal foodstuffs and substances of animal origin intended for the manufacture of fertilizers and foodstuffs
Input (Reproductive Services and		State Corporation Act with respect to	KAGRC	Production, preservation, and conservation of animal genetic material (semen,

[84] Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability, and resilience. Report 3R Kenya/WLR 979.

[85] Kyule et al, 2020 Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

Breeding)		Order No. 112 (2010 /2012) and Gazette Notice No. L.N 110 (2010)		embryo, tissue and live animals) and rearing of breeding bulls for provision of high-quality disease- free semen to meet the national and export demand
Input (Reproductive Services and Breeding		Draft Livestock Breeding Bill (2015)	Proposed:Kenya Livestock Breeding Board	Regulation of livestock breeding andestablishment of a livestock breeding board Training and provisionof equipment to inseminators
Input (Veterinary Services)	Kenya Veterinary Policy (2014)	Veterinary Surgeons and Veterinary para-profession Act (2011/2012)	KVB	Training, registration and licensing of veterinary surgeons and veterinary paraprofessionals and provision for matters relating to animal health services and welfare
Input (Veterinary Services)		Animal Disease Act (1989/2012)	MoALF - Department of VeterinaryServices	Regulating mattersrelated to animal diseases
Input (Veterinary Services)		State Corporation Act(2012/2010) with respect toLegal Notice 223 (1990)	Kenya Veterinary Vaccines Production Institute	Undertaking research and development with respect to new vaccinesand the production and distribution thereof
Input (Research and Extension Training)		Kenya Agricultural and Research Act (2013)	KALRO	Promotion, streamlining, coordination and regulation of agricultural and livestock research and expedition of equitable access to research information, resources and technology and promotion of the application of research findings and technology in the field of agriculture
Input (Research and Extension Training)		Technical and Vocational Education and Training Act (2013)	TVET Board TVET Curriculum Development Assessment and Certification Council	Licensing, registration, and accreditation of institutions and trainers, as and regulation on training institute organization and training quality and relevance
Human Resource Development		Draft Livestock Breeding Bill (2015)	Naivasha Dairy Training Institute Animal Health Institutes ATCs/PTCs	Capacity building and training
Processing (milk bulking, chilling and processing; Feed manufacturing)		Environmental Management and Coordination Act (2012 (1999)/2006)	NEMA	Environmental protection, impact assessment, monitoring and restoration/streamlining of handling transportation and disposal of various types of waste to protect human health and the environment

Table 5 below provides a SWOT on the current regulations, economic instruments, and soft instruments

Table 4: SWOT on Economic and soft Instruments and Regulatory Framework

Institutional context	Strengths	Weaknesses	Opportunities	Threats
Regulations	- The Dairy Industry (Registration, Licensing, Cess and Levy) Regulations, 2021 exist - Regulations on environmental quality and public health exist - *Dairy Industry Act* currently under review confirming the roles of KDB in dairy development and regulation and registration of primary producers - EADRAC established to promote intra-regional trade and development of shared quality standards	- Weak regulatory framework on milk marketing - Uncoordinated and inefficient QA systems for feed, fodder and milk - Poor compliance of milk procurement contracts - Poor compliance with quality and safety requirements - Uncontrolled drug prescription and usage - Concentrated processor segment - Weak governance and management in cooperative sector, resulting in malfunctioning Feed policy developed at national level is yet to be approved	- Development of QA systems for feed, fodder and milk - Regulation and QA of private investments - Formalization of milk traders that may enable better regulatory monitoring - Contract enforcement mechanisms for milk procurements between farmers, CBEs and processors - Enforcement of regulations on drug prescription and use Restructuring of the role of KDB to play a larger role in regulation and compliance	- Increasing regulation of unprocessed milk chain may drive up milk prices
Economic instruments	- Regional trade: free movement of most goods within EAC market - Tripartite regional arrangements involving EAC, COMESA and SADC facilitating regional trade - Beneficial tax regime proposed for investment in processing facilities and feed ingredients - Strong GoK and county government support to and investments in the dairy industry	- Sector support interventions by the GoK and county governments subject to political goodwill	County governments investing in dairy sector support (AI services, sexed embryos, equipment) - Reduction of 60% import levy on dairy products likely to reduce consumer milk price	- Subsidized exports from Europe threat to Kenyan export opportunities to North Africa - Market distortion through subsidized inputs and services by county governments. - Reduction of 60% import levy on dairy products threat for Kenyan milk producers
Soft instruments	- KeBS has developed a Code of Practice for hygienic milk production and handling - KDB and county platforms offer opportunities for consultation among sector actors - Promotion of milk drinking culture through school milk program - Awareness of environmental issues increasing through national	- Actors have insufficiently articulated and shared vision for the sector - Lack of effective and sustainable sector platforms to drive sector vision and agenda - Low compliance with KeBS's Code of Practice	- Strengthen PPPs to address extension and service delivery and marketing - National promotional campaigns of nutritive value of milk	[86]

[86] Ibid

	education systems and media coverages			

Cess, levies, and taxes

The KDB collects statutory revenues classified as cess, levies, penalties, licenses or permits to dairy sector players to raise funds needed to exercise regulatory and promotional functions under its mandate in the DVC. However, many chilling hubs do not see benefits accruing from the statutory payment and instead see it as constraining the growth of their business87. A license and a regulatory permit are issued by Kenya Dairy Board to dairy business operators. A holder of a regulatory permit shall be an agent of the Board for the purpose of collecting and remitting the consumer safety levy. A dairy business operator shall remit a consumer safety levy on the dairy produce processed or imported at the rate of forty cents per kilogram of milk processed or one per centum of the cost of milk processed or imported, whichever is higher88.

Rademaker 2016 notes that statutory revenues are collected from processed traded milk, which is only 30% of total milk traded because most farmers and cooperatives operate on the raw milk market by selling to neighbors and milk traders. Processors are concerned that this creates an unfair playing field, as they in addition to paying the KDB levies and licenses, they are paying VAT and taxes, while people operating on the unchilled, raw milk market are not.

Import tariffs

The EAC has a free trade arrangement for dairy products excluding infant formula and a 60% Common External Tariff (CET) for dairy products from outside the EAC. The separate EAC states charge additional 15% VAT to the CET. The 60% CET protects the domestic milk industry, which some actors consider too high an import tariff and the main factor for high consumer (processed) milk prices89
etc?

Dairy policy and regulations are mainly implemented through the KDB. Others are the state Department of Livestock, the Ministry of Health, and the Kenya Bureau of Standards. To date, most KDB actions have tended to protect the interests of large-scale processors; despite the fact informal milk marketing remains the dominant marketing channel handling over 80 percent of marketed milk. As a result, bureaucratic pressures, as well as commercial and political biases, have threatened informal trade.
In 2004, there was a policy to support small-scale milk traders and KDB licensed over 4,000 traders who sell raw milk through milk bars. However, in a circular issued by the KDB in January 2013 citing public health safety concerns, traders were required to only trade in processed milk and milk hawking was banned. Most traders in the studied regional block counties sell raw milk. This policy is therefore a major hindrance to dairy development in these counties unless measures are put in place to address the quality and safety concerns raised by KDB.
Challenges facing the sector include poor roads and transport networks, unsafe water and sanitation facilities, inadequate milk storage and preservation infrastructure, and unreliable rural electricity supply that increase the cost of production, processing, and marketing.

87 Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979.
88 Dairy Regulations 2021
89 Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979.

Cooperation with government and donor projects

Business Enabling Environment Kenya's institutions responsible for developing the dairy sector, especially public institutions and farmers' and traders' associations, are not adequately developed to provide effective support to the value chain. Neither public nor private institutions are reported to be proactive in developing a vision for the development of the sector. Kenya has one of the most developed networks of public and private dairy research institutions in Africa, with several public and donor-funded national and multinational breeding and research programs. Critical to their future contribution will be speeding up knowledge transfer to smallholders, particularly in promoting the adoption of animal breeds appropriate for different ecological conditions.

Development of the dairy value chain to serve the needs of a growing population, requires an enabling legal and regulatory environment targeting industry growth. The current policy framework is focused on diminishing the dominance of informal markets, through formalization of milk trade. However, informal markets continue to dominate the industry handling over 80 percent of marketed milk supplies (mostly in raw form) but presenting public health concerns. Future development of the dairy value chain therefore critically depends on streamlining the informal sector and implementing dairy regulations that promote the small-scale dairy traders while ensuring compliance to quality and safety standards. This can be achieved through cooperation of private and public partners.

State infrastructural elements

Transport

Road infrastructure has an important influence on the returns to smallholder dairy production, especially in the informal market that dominates the dairy subsector. Farmers far from large demand centers tend to receive lower returns for milk than those closer to the demand centers. For instance, farmers 75 kilometers or more from Nairobi get 22 percent less for their milk, on average, than farmers close to the city. Each additional kilometer of poor access road to the main road reduces milk price by some 0.50 shillings per liter, or about 3 percent per kilometer. Importantly, the impact of road infrastructure becomes more significant during the rainy seasons, when heavy rains and flooding render most access roads impassable. This greatly affects the prices offered to farmers and the cost of delivering milk off the farm[90]

Electricity

Kenya does not generate enough electricity to meet demand, and the national monopoly, Kenya Power fails to distribute the available electricity efficiently.[91] National electric grid coverage remains woefully low, power shortages and outages are the norm, and electricity is too expensive for most households and businesses. The Kenya Rural Electrification Program was supposed to alleviate some of these bottlenecks but, due to financial constraints and inefficient power distributors, progress has been slow. Without adequate and reliable electric power, primary milk processing, storage and value addition in most rural areas will remain difficult and expensive. In addition, lack of reliable electricity makes the storage and preservation of animal health (medicine, vaccines, etc.) and breeding (semen) supplies more expensive to service providers.

Storage Facilities

[90] Muriuki, H. G., & Thorpe, W. (2001). Smallholder dairy production and marketing in eastern and southern Africa: Regional synthesis. *Smallholder dairy production and marketing–opportunities and constraints*.

[91] Boamah, F. (2020). Desirable or debatable? Putting Africa's decentralised solar energy futures in context. *Energy Res* Jabeen, S., Haq, S., Jameel, A., Hussain, A., Asif, M., Hwang, J., & Jabeen, A. (2020). Impacts of rural women's traditional economic activities on household economy: Changing economic contributions through empowered women in rural Pakistan. *Sustainability*, *12*(7), 2731. *earch & Social Science*, *62*, 101390.

Rural milk storage (cooling) and pasteurization facilities are largely nonexistent. Milk produced by smallholders must be disposed of immediately to avoid losses through spoilage. Installed bulking and cooling capacity is inadequate, with a cooler installed capacity of 2.7 million liters against a daily production of 14.2 million liters. The level of utilization is good at 95 percent. Those not currently being utilized have challenges of breakdowns, and inaccessibility to most smallholders. Given the poor infrastructure and high cost of installation and operation, the additional cost of bulking and cooling milk makes it unattractive to most smallholders in the price-competitive market.

Overall, the poor state of storage facilities and roads contributes to high production costs, low sale prices, and high milk handling losses. The decline in investment in rural infrastructure after trade liberalization, such as rural access roads, has affected rural marketing organization and limited the ability of smallholder farmers to negotiate better market prices. The debate over the exact impact of rural accessibility on milk markets remains unresolved but is believed to be substantial, especially during the rainy season when milk supply is highest. The effect of remoteness could be more manifest in the access to input markets and animal services. Since animal health and breeding are time-sensitive activities, private input and service providers must locate within their areas of operation. Low financial returns may dissuade them from setting up in certain regions.

Socio-cultural elements

Men and women are engaged in most of the dairy production and marketing activities. Most dairy activities at the household level are largely performed by women.[92] Although some tasks are shared, women still allocate relatively more time than men to dairy farming. Women mostly perform delivery of milk to the market (especially when transported on foot), cleaning milking equipment, animal collection, watering, fodder collection and feeding, and add value to milk through traditional milk processing. Men's tasks include cattle spraying, construction, and maintenance of cattle pens, keeping general animal health and animal breeding. Some of the shared dairy tasks include cattle feeding, grazing, and milking. Girls and boys support women and men's tasks respectively. When feeding involves cut and carry of feeds, women were more likely to be involved and men were mostly involved in open grazing of animals. The rapidly changing dairy feeding systems from open grazing to cut and carry, happening across most of the areas surveyed, are changing gender roles, tasks, and workload in the household. [93]

Decisions on use of proceeds from the sale of fresh milk vary by marketing channel, volume of milk sold, and the breed type kept. Decisions over fresh milk proceeds are made jointly. In most counties in western Kenya region (Vihiga, Migori and Siaya), women control proceeds from fresh milk sold probably due to low volumes of production and little proceeds. However, the situation is changing as farmers shift from local breeds to improved breeds. Proceeds from traditionally processed milk are traditionally handled by women and this is not likely to change soon until men get enlightened about the value of this milk.

Similarly, the decisions of where to sell milk is dependent on volume of milk produced, breed type, price offered and available marketing channels. In counties where milk production is low (Vihiga, Busia, Migori, Siaya and, Homa Bay), decisions on where to sell are dominated by women. These trends are likely to remain the same in the next five years. Decisions over selling of heifers is mainly done by men, in areas where dairying is not well developed,

92

93 Perrin, A., & Martin, G. (2021). Resilience of French organic dairy cattle farms and supply chains to the Covid-19 pandemic. Agricultural Systems, 190, 103082.

otherwise it is a joint decision. The same was reported on breeding and bull selection, even though a few times women take such decisions.[94]

Consumption varies by origins, religion, age, and other demographic factors. Raw milk was preferred over pasteurized, ultra-high temperature treated, and powdered milk because it was cheaper and widely available. To improve consumption of different milk products, there is need to improve availability particularly in the rural areas[95].

2.5.2 Natural environment

- How is the value chain related/ linked/ depended on water, biodiversity, and climate?

Water

Water is a very important component in dairy development. However, reliable, and clean water is not adequately available for dairy animals, especially during the dry seasons. There have been cases of water conflicts posing a challenge to dairy activities. Dairy farms also use freshwater mainly to provide drinking water to animals and to carry 358 out on-farm cleaning activities (e.g., barn, milking equipment and milk storage tank) Increased demand for livestock products can overburden freshwater resources needed to sustain that production.[96]

The highest proportion of water utilized along the dairy value chain goes into feed production. Different feed products have different water footprints. The assessment of the water footprint of livestock production systems has created the need to quantify the utilization of this resource, to establish management measures in the sectors with high demand for raw materials such as dairy farming. Therefore, increasing the efficiency of water usage in the dairy production sector will improve the sustainability of the livestock systems and minimize potential impacts on water resources.

Cows in lactation consumed the most water (1,737 m3/year) while calves (22 m3/year) and heifers (247 m3/year) were the least. The proportion of drinking water consumed was 3.75% of the total water footprint of milk. However, service water, which is mainly used during milking, cleaning, and cooling of animals, accounted for 9% of the total water usage, with wide differences between farms (ranging from 7 to 12%).[97]

Biodiversity

Livestock systems destroy species habitats when forest is converted to pasture or feed crops, but grazing is the only way to maintain semi-natural grasslands that have existed for hundreds of years and host a rich and unique biodiversity.[98] Grazing is vital for the conservation of habitats and species in traditional habitats. Cultivating a diverse range of plant species and varieties for grass forage increases the diversity of the agricultural environment. At the same time, the adverse impacts caused by extreme weather phenomena are mitigated. Dairy farmers depend on natural resources, including fertile soil, sufficient and clean groundwater, and the availability of minerals.

Climate

Dairy cows have difficulties coping with high temperatures and they are susceptible to experiment heat stress leading to the milk yield reduction, mortality increase and fertility rate decrease. Increment in temperatures because of climate change is expected to accentuate heat stress. The rise of temperatures might also influence milk

[94] Basu, P., Galiè, A., & Baltenweck, I. (2019, May). Presence and property: Gendered perspectives on participation in a dairy development program in Kenya and Uganda. In Women's Studies International Forum (Vol. 74, pp. 68-76). Pergamon.

[95] Mtimet, N., & Karugia, J. T. (2020). Consumer perception of milk safety in Kenya.

[96] Wang, Y., & Serventi, L. (2019). Sustainability of dairy and soy processing: A review on wastewater recycling. *Journal of Cleaner Production*, *237*, 117821.

[97] Ibidhi, R., & Salem, H. B. (2020). Water footprint and economic water productivity assessment of eight dairy cattle farms based on field measurement. *animal*, *14*(1), 180-189.

[98] Meybeck, A., & Redfern, S. (2016). Sustainable value chains for sustainable food systems. In *Joint FAO/UNEP Workshop on Sustainable Value Chains for Sustainable Food Systems Rome (Italy) 8-9 Jun 2016*. FAO/UNEP.

quality.[99] Climate change is expected to increase mastitis occurrence in lactating cows, meaning an increment of these biological hazards in raw milk.[100] Climate change as a driver of emerging risks for food and feed safety, plant, animal health and nutritional quality (Vol. 17, Issue 6).

Competitive advantages and weaknesses

Key strengths[101]

• Robust private sector driven processing industry, built up over the last 20 years.
• Nationwide availability and steadily increasing variety of dairy products for all consumer groups.
• Ongoing investments in value-added products, including long-life milk and milk powder.
• An emerging dairy export sector.
• High demand for processed milk and milk products due to a growing urban (lower and) middle class
• 365 days/year milk collection by traders, dairy societies, and processors in all high potential dairy production areas from hundreds of thousands of smallholders.
• Emerging segment of commercial dairy farmers with ability to invest and innovate.
• A wide distribution network and good access to commercial input suppliers and service providers.
• Conducive trade policies (zero-rating, import duties on milk products).
• Available dairy genetic base that can be improved upon with proper breeding policies.

Key weaknesses

• Low skills and knowledge level of almost all farmers (small, medium, and large-scale).
• Low level of commercialization by smallholders (dairy not the core business).
• High cost and seasonality of raw milk production due to low ability/skills to produce and preserve quality fodder.
• Inefficient and high cost of milk collection and cold chain development (hence: High cost and low quality of milk at factory gate).
• Lack of loyalty between value chain actors and high fragmentation.
• Lack of credible input suppliers and service providers.
• Large raw milk market and lack of level playing field for the formal sector.
• Lack of clarity on a common vision among stakeholders about how to steer the dairy industry into a more sustainable growth path.
• Ineffective sector regulation: Policies in place, but not enforced on the ground,

[99] Hempel, S., Menz, C., Pinto, S., Galán, E., Janke, D., Estellés, F., Müschner-Siemens, 953 T., Wang, X., Heinicke, J., Zhang, G., Amon, B., Del Prado, A., & Amon, T. 954 (2019). Heat stress risk in European dairy cattle husbandry under different climate change scenarios-uncertainties and potential impacts. Earth System Dynamics.

[100] EFSA. (2020). Climate change as a driver of emerging risks for food and feed safety, plant, animal health and nutritional quality (Vol. 17, Issue 6).

[101] Rademaker, I. F., Koech, R. K., Jansen, A., & Van der Lee, J. (2016). Smallholder dairy value chain interventions. *The Kenya Marketled Dairy Programme (KMDP) Status report. SNV Kenya/Wageningen UR CDI*.

3 Sustainability Assessment

3.1 Economic Analysis

3.1.1 Profitability

Under processor-oriented chains, processors realize the biggest share of revenue per litre of fresh milk (45–47 percent), followed by producers (32–38 percent), while Milk Collection Centres (MCCs) realize a meagre 3–7 percent. Under the milk dispensing technology linked to supermarkets (such as in Kiambu), producers realize the biggest share of revenue (58 percent), followed by the supermarkets (23 percent) and the MCC (12 percent)[102].

Under the informal milk traders' system, milk traders (in Nandi) and producers (in Kiambu) realize the biggest share of revenue, at 54 percent and 74 percent, respectively. In all cases, MCCs realize the lowest share of revenue yet they are crucial in linking women dairy producers to milk markets and for accessing a range of interlocking dairy inputs and services, and thus their profitability is important. Increasing volumes of milk bulked and managing debt obligations are the major factors influencing their financial health[103].

Table 6 below shows a comparison of producer prices across various Counties in 2014 and 2019.

Table 5: Comparison of producer prices (various counties)

2014			**2019**		
County	**Price**	**Main buyer**	**Price**	**Main buyer**	**nge in price (KES)**
Machakos	34.7	Dairy Coop	60.0	Hotels	25.30
Muranga	28.7	Dairy Coop	33.7	Dairy Coop	4.97
Nyeri	28.9	Dairy Coop	30.0	Dairy Coop	1.10
Nakuru –Bahati	30.0	Traders	30.7	Traders	0.74
Embu	32.4	Traders	31.7	Processor	-0.73
Kiambu	36.8	Dairy Coop	35.0	Dairy Coop	-1.80
Meru	35.0	Traders	30.0	Dairy Coop	-5.00
Bomet	30.5	Processor	42.5	Traders	12.00
Bungoma	49.9	Consumers	60.0	Consumers	10.10
Nyandarua	27.5	Dairy Coop	29.0	Dairy Coop	1.50
Kisii	50.0	Consumers	50.0	Consumers	0.00
Trans Nzoia	30.7	Traders	30.0	Dairy Coop	-0.70
Kakamega	60.0	Consumers	50.0	Consumers	-10.00
Baringo	27.9	Dairy Coop	32.7	Dairy Coop	4.80
Uasin Gishu	28.5	Dairy Coop	30.1	Dairy Coop	1.60
Nandi	30.3	Dairy Coop	29.5	Traders	-0.80
Elgeyo Marakwet	29.4	Dairy Coop	27.7	Dairy Coop	-1.70
Trans Nzoia			32.7	Dairy Coop	--
Narok	30.6	Processor	39.7	Traders	9.10
Uasin Gishu			29.8	Dairy Coop	--
Nakuru				29.8 Dairy Coop	
Average price	**34.5**		**37.4**		**2.9**

Source[104]

[102] FAO, 2017 Gender assessment of dairy value chains: evidence from Kenya,
[103] Ibid
[104] KDB, 2021

Table 6: Costs and returns in KES per litre of milk by production system

Item	Meru, Nyeri, Muranga, Embu, Kiambu, Machakos, Nakuru **Zero grazing**	Kisii, Bomet, Kakamega, U/Gishu, Nyandarua, Bungoma, T/Nzoia, Nandi, Marakwet, Nakuru **Semi-zero grazing**	Narok, Uasin Gishu, Nakuru **Open**	**Overall**
Gross revenue from milk (sold + consumed)	35.87	37.27	31.00	34.71
Purchased fodder/pasture	3.87	0.56	0.00	1.48
Feed concentrates	7.05	2.24	2.92	4.07
Mineral salts	0.56	0.69	0.21	0.49
Water (purchased)	0.62	0.04	0.06	0.24
Health and breeding costs	1.14	1.93	1.68	1.58
Milking jelly	0.26	0.16	0.22	0.22
Hired labour	3.98	4.90	5.34	4.74
Repairs on fixed assets	0.15	0.16	0.13	0.15
Other direct costs (e.g. electricity, fuel)	0.19	0.00	0.00	0.16
Total variable and directs costs (TVDC)	**17.81**	**10.69**	**10.57**	**13.02**
Gross margin (Revenue - TVDC)	**18.06**	**26.57**	**20.43**	**21.69**
Depreciation (fixed assets)	0.40	0.31	0.15	0.28
Own fodder/pasture	4.16	5.77	5.68	5.21
Family labour	4.93	6.22	0.84	4.00
Total costs (TC = TVDC + depreciation + opportunity cost)	27.30	23.00	17.24	22.51
Milk profits (revenue - TC)	**8.57**	**14.27**	**13.76**	**12.20**
Other revenue (sale of livestock, manure, bull services)	1.86	4.16	5.98	4.00
Whole enterprise profit	**10.43**	**18.43**	**19.74**	**16.20**
Gross margin/TVDC ratio	1.01	2.49	1.93	1.81
Gross margin rate (%)	50.34	71.31	65.91	62.52

Source[105]

Using KAVES baseline data and sample data from milk bulking and dispensing enterprises collected in December 2013, this report estimates that dairy farmers received the highest share of the final price at 35 percent, followed by milk dispensers at 33 percent. Along the value chain, milk producers realized 56 percent margins per liter of milk, bulking centers 15 percent, trader's 10-20 percent, and dispenser's 30 percent. The average unit cost of production is KSh17 per liter, with feed and labor accounting for over 84 percent of the total cost.

The margins analysis shows dairy farming is profitable, with the value of milk produced increasing by 3.2 times (KSh53) from the farm gate to the final consumer dispensing units. Farmers earned an average KSh32 per liter of milk sold, generating about KSh172,000 in enterprise income per year (≈KSh47,000 per cow). As an economic activity, the average dairy enterprise easily satisfies the minimum annual consumption expenditure requirements of individual rural households. To be economically viable as the only source of household income, however, an average dairy farmer requires at least three cows. Our analysis suggests that interventions targeting the reduction of costs for feed and labor and increased productivity will maximize small-scale farmer returns in the dairy sector[106].

[105] Report on a study on cost of milk production in Kenya, KDB 2021

[106] Kenya, K. A. V. E. S. USAID-KAVES.

3.1.2 Employment

The dairy industry is estimated to generate 76 jobs for every 1000 litres of milk sold. Specifically, at the input and production level, about 23 full-time self-employed jobs, 50 permanent full-time jobs for employees and 3 full-time casual jobs are generated. For the same amount of milk produced, more than 13 jobs are created within the processing stage. With the Kenya's population projected to rise by about 35 per cent by the year 2030, the demand for milk is likely to increase, consequently increasing; more on- farm and off-farm employment opportunities.

However, the number of youths employed in the sector is still few, especially in the formal sector with many of them engaged in the informal milk trade and transportation on motorbikes. With increased consumption of processed dairy products, additional decent job opportunities in the formal milk channel can be created because of increased milk processing.

Poor infrastructure such as road networks, electricity and water also hinder growth of the dairy industry for job creation. The firms involved in manufacturing tasks along the dairy value chain experience a considerable loss due to power outages. These outages result in low production levels, which in turn affects the total number of persons employed in the firm. More jobs for unemployed youth can be generated if this constraint is addressed, resulting in increased productivity. In addition, poor road networks and marketing infrastructure in rural areas lead to delays in delivering milk to cooling and bulking facilities.

3.1.3 Opportunities for Value Addition

The industry is mainly driven by liquid raw milk but there is growing demand for processed dairy products such as Fresh Pasteurized milk, Yoghurt-, Fermented milk (Lala), Long Life milk-UHT and ESL, Butter, Fresh cream, Cheese and Ice Cream especially among the middle and upper income within the urban areas[107]

The key product categories within the processed dairy products category includes: -

- **Conventional** – Processed dairy products for the middle class, with focus on volumes, market share and profit, and less focus on quality.
- **Niche** – Quality products such as cheeses and healthy dairy products for upmarket consumer segments; these require QA systems along the DVC to ensure milk intake that is free of antibiotics, aflatoxin and deliberately introduced hazardous substances; the price premium covers extra costs
- **Local bulk** – Raw milk marketing with emphasis on low costs, trust, speed and/or affordability for consumers; it ranges from home delivery to milk bars to ATMs in supermarkets[108].

3.1.4 Effects in the county and national economy

The dairy sub-sector, which accounts for about 15% of Kenya's total agricultural sector's gross domestic product, contributes substantially to the national economy and aims to play a significant role in achieving the 10% economic growth stipulated in Kenya's Vision 2030 blueprint document. Dairy production provides many non-marketed economic benefits, including manure for use on-farm as fuel or organic fertilizer (in several farming systems manure is the sole source of nutrients for crop production)[109].

At the farm level, for every 1 000 liters of milk produced daily, dairy activities generate an estimated 23 full-time jobs for the self-employed, 50 permanent full-time jobs for employees, and three full-time casual labor jobs, making

[107] Kyule, et al 2020. Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

[108] Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979.

[109] Rademaker, C. J., Bebe, B. O., Van Der Lee, J., Kilelu, C., & Tonui, C. (2016). *Sustainable growth of the Kenyan dairy sector: a quick scan of robustness, reliability and resilience* (No. 979). Wageningen University & Research, Wageningen Livestock Research.

a total of 77 direct farm jobs per 1 000 liters of daily milk production. This translates into a total of about 841 000 full-time jobs generated by dairying at the farm level

Dairy development makes a significant contribution to poverty reduction, both at household and community level and this has implication on national and county government's economy.

Table 7:Economic Contribution of the dairy sector

Indicator	Estimated Value
Value of dairy contribution to overall GDP (%)	4
Value of dairy contribution to agricultural GDP (%)	12
Value of dairy contribution to the livestock GDP (%)	44
Number of lactating dairy cattle (million)	4.50
Annual milk production from all livestock (million litres)	4.75
Total annual milk production cows (billion litres)	3.56
Per capita consumption of milk per year (litres)	121
Amount of formally marketed milk per year (million litres)	600
Number of smallholder dairy farmers (million)	1.8
Number of indirect jobs created annually	750,000
Number of direct jobs created annually	500,000

Source[110]

3.1.5 International competitiveness

For any enterprise to be competitive in its market environment, it should exhibit at least 'normal' profits. Normal profits are those that offer the same return to investment (such as of land, labor, and capital) that would be available from alternative enterprises locally. In the case of labor, for example, a normal profit would approximate the wages available to the entrepreneur elsewhere in the market. Any enterprise that exhibits above normal profits may be regarded as rewarding investment at a better level than most local enterprises and so can be considered competitive[111]. The increasing importance of dairy to the Kenyan economy means that the international competitiveness of the economy is very important. More importantly, globalization and trade liberalization coupled with the easy flow of information and advancement in transportation and communication technology have resulted in an unprecedented intensification of market competition worldwide[112].

The global performance of the dairy industry has been declining due to factors such as reduction of market share, reduced profits, loss of customer satisfaction, stiff competition, and lack of appropriate management strategies[113]. Kenya has the largest dairy sub-sector in eastern and southern Africa making available annually an estimated 85-90 liters of liquid milk equivalent per capita based primarily upon well-established market-oriented smallholder dairy systems.

3.1.6 Value for end-consumers

Food and nutrition security refers to a situation where all people always have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

[110] Kyule, et al 2020. Exploring Kenya Dairy Industry for Job Creation for the Youth, KIPPRA Discussion Paper No.232

[111] Rangnekar, D., & Thorpe, W. R. (2001). Smallholder dairy production and marketing—Opportunities and constraints. ILRI Proceedings.

[112] Ohlan, R. (2012). Global competitiveness in dairy sector. Available at SSRN 2797987.

[113] USDA. (2019). 95th Annual Agricultural Outlook Forum, Growing Locally, Selling Globally. USDA, United States Department of Agriculture. Washington

The importance of milk in the human diet especially for children and expectant and nursing matter is vital. Given milk's nutritional quality, there is growing evidence of the role of dairy foods in reducing risk of numerous medical disorders. The nutritional value of milk is high and of value when it is included in the diets of growing infants and lactating mothers.[114] Milk is regarded as a whole food, providing energy, protein, vitamins, and minerals in human diet. It can therefore correct for malnutrition and nutrient deficiencies especially in children and young adults[115].

3.2 Social Analysis

3.2.1 Inclusiveness

Family members men, women and children contribute labour for the success of the enterprise. However, there are workload disparities depending on several factors, including ethnicity, traditional gendered division of labour, production system, and household socio-economic characteristics[116]. Studies observe that women predominate in activities that are performed daily such as milking, feeding, and watering, while men are mainly involved in tasks performed weekly or seasonally such as spraying or planting forage[117]. Selling milk is participated in by both gender depending on intra-household factors, type of market outlet, proximity to milk collection and transportation arrangements. Family labour may not be adequate to run the dairy production unit hence hired labour that contributed about 50 percent and 75 percent, respectively, of total labour required in running dairy enterprises in rural and peri-urban areas[118]. Involvement of school going children in most of the areas under value chain study is low and restricted to weekends and holidays[119].

The income from milk is relied on to meet a diverse range of financial needs in addition to domestic provisioning. These include school fees, healthcare, loan repayments, contributions to community welfare activities, participation in merry-go-rounds (informal savings and credit groups) as well as household consumables and assets. Because of the unique ability of dairy production to ensure a regular flow of milk revenue, income from milk sales was highly relied on to meet pressing household financial obligations. Females have access to this income but do not have much leeway in deciding how to spend it.

3.2.2 Gender equality

The roles played by men and women in the dairy value chain are influenced by the gender division of labour and therefore tend to vary depending on the prevailing milk production and marketing systems. Under the traditional production system, women contribute most of labour in dairy production, and contributed even more under intensified small-scale operations The Kenyan dairy value chains are relatively short and can broadly be categorized

into cold or pasteurized (formal) and warm or unpasteurized (informal) supply chains. These chains differ in terms of size, geographical distribution, degree of licensing, relative rewards, quality perceptions and long-term potential. The field survey reveals that: women's participation is highest at the production node; at the milk traders' node, women operate at a smaller scale and experience more severe challenges related to access to capital, improved

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[114] Picciano, M. F. (2001). Nutrient composition of human milk. Pediatric Clinics of North America, 48(1), 53-67.

[115] Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. Journal of cleaner production, 112, 9-21.

[116] Njarui, D. M. G., Kabirizi, J. M., Itabari, J. K., Gatheru, M., Nakiganda, A., & Mugerwa, S. (2012). Production characteristics and gender roles in dairy farming in peri-urban areas of Eastern and Central Africa. *Livestock Research for Rural Development*, *24*(7), 2012.

[117] Njuki, J., Kaaria, S., Chamunorwa, A., & Chiuri, W. (2011). Linking smallholder farmers to markets, gender and intra-household dynamics: Does the choice of commodity matter?. *The European Journal of Development Research*, *23*(3), 426-443.

[118] Njarui, D. M. G., Kabirizi, J. M., Itabari, J. K., Gatheru, M., Nakiganda, A., & Mugerwa, S. (2012). Production characteristics and gender roles in dairy farming in peri-urban areas of Eastern and Central Africa. *Livestock Research for Rural Development*, *24*(7), 2012.

[119] Katothya, G. (2017). Gender assessment of dairy value chains: evidence from Kenya. *Gender assessment of dairy value chains: evidence from Kenya.*

technology, information, and mobility than their male counterparts; the milk transportation service is almost exclusively reserved for male youth; employment at Milk Collection Centres (MCCs) is also male dominated, especially in management; there are few women who own dairy support services businesses such as agrovet stores; and most agrovet stores prefer to employ young women as store attendants.

Gender-based barriers affect market participation in various ways. Gender norms often assign non-remunerated activities, such as domestic work, to women, which reduces women's time and energy to generate income through value chains. Women often have limited access to and control over assets relative to men, which limits their capacity to engage in more profitable activities within a value chain and in more lucrative value chains.[120]

Horizontal segregation is equally manifest. Women play a predominant role at the production node, taking care of cattle, milking, processing, and marketing milk; men, and to some extent children, play supportive roles as family members or hired labour. Women's roles at these nodes are, to a large extent, performed daily and within the homestead[121].

3.2.3 Food and nutrition security.

Dairy sector Contributes directly to food security (through milk consumption) and indirectly (through income generation) from milk products.

Dairy farmers mostly have prolonged food availability compared to nondairy farmers. This is likely due to increased crop outputs from gardens of dairy farmers compared to nondairy farmers. The availability of cash from milk sales also enables dairy farmers to purchase staple food thereby increasing their resilience to challenges that might result from natural shocks including those related to climate change and variability[122].

3.3 Environmental Analysis

3.3.1 Climate change

The dairy sector faces several environmental challenges with respect to soil erosion, water pollution, waste and manure management and greenhouse gas emissions. However, there is limited awareness of the environmental impact of the sector.[123],[124] The prevailing mixed farming systems offer opportunities to address some of these challenges, for example, through use of manure for crop fertilization.[125] There are ongoing efforts to mainstream environmental issues in the sector with upscaling of climate smart agriculture, both for addressing climate change and for dairy development. Erosion and water pollution Negative environmental impacts of the dairy sector in Kenya include loss of vegetation through overgrazing of natural pastures. As extensive grazing is mostly practiced in the Rift Valley region, uptake of more intensive dairy production across ecosystems in the country is contributing to

120 Quisumbing, A. R., Rubin, D., Manfre, C., Waithanji, E., Van den Bold, M., Olney, D., ... & Meinzen-Dick, R. (2015). Gender, assets, and market-oriented agriculture: learning from high-value crop and livestock projects in Africa and Asia. Agriculture and human values, 32(4), 705-725.

121 Banda, L. J., Chiumia, D., Gondwe, T. N., & Gondwe, S. R. (2021). Smallholder dairy farming contributes to household resilience, food, and nutrition security besides income in rural households. Animal Frontiers, 11(2), 41-46.

122

123 Kopf, S., Colvin, A. C., Muriuki, M., Zhang, X., & Harner, C. D. (2011). Meniscal root suturing techniques: implications for root fixation. The American journal of sports medicine, 39(10), 2141-2146.

124 Makoni, N., Mwai, R., Redda, T., van der Zijpp, A. J., & Van der Lee, J. (2014). White gold: Opportunities for dairy sector development collaboration in East Africa (No. 14-006). Centre for Development Innovation, Wageningen UR.

125 Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H. A., ... & Rosegrant, M. (2010). Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science, 327(5967), 822-825.

changes in land use, with more land needed to produce feed for dairy cows. Another issue is surface water pollution from bulking and processing activities.[126]

The sector is highly vulnerable to extreme weather events, climatic shocks, climatic changes, and variability. Climate change is creating further stresses on food and water supply while further degrading the environment. It is estimated that between 2008 and 2011, drought which is a major climatic hazard in Kenya became increasingly frequent (Kenya climate smart agriculture Implementation framework 2018-2027)

The role of livestock in GHG emissions cannot be understated. The agricultural sector is the largest source (58.6%) of total GHG emissions in Kenya, and livestock related emissions account for the overwhelming majority (96.2%) of those emissions. The dairy cattle sector in Kenya is responsible for about 12.3 million tonnes CO2 eq. GHG emissions at the dairy factory are associated with raw milk collection, on-site processes, packaging material provision, milk losses and wastewater treatment.

At national level, the emission intensity of milk produced in Kenya is on average 3.8 kg CO2 eq./kg FPCM; the highest values were estimated for extensive grazing systems and the lowest in semi-intensive systems. Emissions were on average, 7.1, 2.1, and 4.1 kg CO2 eq./kg FPCM for extensive, intensive, and semi-intensive systems, respectively[127].

Reducing enteric CH4 via increasing productivity is economically viable in most situations; several activities that reduce methane emissions have low or negative economic cost when considering the increase in production. Economically attractive measures are those that have a negative cost or savings meaning there is a net financial benefit. Interventions should have negative net costs (i.e. net benefits). Putting the reduction potential and net costs together allows a first order prioritization of low carbon interventions. All other things equal, the objectives would be to promote interventions with high reduction potential and a net economic benefit[128].

Despite great potential, Kenyan smallholder dairying faces diminishing land sizes, high input costs, poor extension contacts, non-responsive price policies, and new pests and diseases. Climate change will worsen the situation[129]. Global warming and the associated climate change is expected to exacerbate the challenges smallholder dairy farmers in Kenya face, as it would lead to more crop failure and famine, with many plant and animal species having problems adapting[130].

Table 1 below shows climate hazards, impacts, implemented practices and adaptation recommendations in the dairy sector that were identified in the prefeasibility study[131].

Table 8: Dairy Value Chain Climate Hazards, impacts, practices, and recommendations (source, prefeasibility study)

[126] Kopf, S., Colvin, A. C., Muriuki, M., Zhang, X., & Harner, C. D. (2011). Meniscal root suturing techniques: implications for root fixation. The American journal of sports medicine, 39(10), 2141-2146.
[127] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2017. *Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods*. Rome. 43 pp.
[128] Ibid
[129] Adaptation of Smallholder Dairy Farmers in Southwestern Kenya to the Effects of Climate Change Charles Okech Odhiambo1*, Harun Okello Ogindo2, Chlirukovian Bwire Wasike3, Washington Odongo Ochola4
[130] Ibid
[131] Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc, Kenya (CRLCSA)Prefeasibility Study, 2022

VALUE CHAIN STEP	CLIMATE HAZARD	CLIMATE IMPACTS	IMPLEMENTED PRACTICES	ADAPTATION RECOMMENDATIONS
Input supply	Droughts	Reduced quality and quantity of pasture and fodder; increased infertility and costs of breeding; reduced access to credit for agricultural inputs	Improved feed conservation and diversification (e.g., organic-crop residues, herbs, branches, shrubs, and grass)	Introduction of drought tolerant pasture; development of feed storage facilities; training on fertility cycle monitoring and input subsidies to farmers; establishment of emergency fund to insure producers; introduction of drought- and disease-tolerant breeds
	Flooding	Limited access to inputs due to negative effects to input transport, storage, and marketing facilities; reduced quality of pasture and feed	Use of locally available breeds; improvement of feed conservation; drainage systems (channels/trenches) in fodder fields and livestock sheds; use of alternative inputs (traditional herbs); repair damaged roads to ease access to inputs	Improve infrastructure to facilitate access to inputs; government provision of dairy inputs (e.g., drugs, feed; concentrates); capacity building in fodder production and conservation strategies
Production	Droughts	Increased vulnerability to pests and diseases due to reduced immunity and poor feeding; emaciation of livestock; drought stress on animals	Use of locally available drugs for pest and disease control; diversification of production (e.g., crop production, introduction of goats)	Improved access to veterinary services and insurance schemes; improved pests and disease control systems
	Flooding	Increased pests and water-borne diseases risk; reduced milk production due to lower quality of animal feed	Use of traditional inputs (e.g., local herbs) for integrated pest and disease control; digging trenches for flood water drainage	Improved pest and disease control systems and advisories; capacity building in soil and water conservation and on improved drainage systems
Harvesting, storage, and processing	Droughts	Increased costs for collection of milk and pastures/fodder; increased milk spoilage; reduced water resources	Reduction of amounts of milk delivered to aggregation centers.	Establishment of climate-proofed milk processing plants (e.g., for milk powder and long-life milk) and cold chain facilities.
	Flooding	Damage to road infrastructure and reduced access to storage and processing facilities; damage to fodder and milk storage infrastructure; rapid food spoilage	Increased feed storage and conservation in sheds; repairing of damaged roads to access pasture fields and storage facilities; introduction of value addition activities (e.g., powder milk, fermentation)	Establishment of climate-proofed milk collection and processing plants; strengthen use of flooding early warning systems
Markets	Droughts	Higher costs for milk traders in milk sourcing and reduced quantity of milk at markets	Reduced milk marketing activities and prices at the farm gate	Improve access to high-end markets; increase farmers' access to insurance products and contract milk farming
	Flooding	Reduced access to market facilities and damage to infrastructure; reduced income from milk production; reduced market activities and opportunities; job losses for processors and transporters		Establishment of community-based milk collection and storage facilities; improved dairy farmers' access to insurance product and contract milk marketing

3.3.2 Water foot print

The complete dairy value chain is made up of several process steps, starting with the production of fodder and ending with the processed dairy product on the table of the final consumer. All the stages of production use water in the process of adding value to the product. The complete dairy value chain is made up of several process steps, starting with the production of fodder and ending with the processed dairy product on the table of the final consumer.

3.3.3 Biodiversity and ecosystems

Many development efforts emphasize breeding for improved dairy cow performance, usually meaning higher milk yields. These efforts promote superior genetic material that is mainly exotic dairy breeds. These development strategies expose indigenous cattle breeds such as Zebu to increased risk of extinction. At least from the perspective of agrobiodiversity and resilient production systems, conservation of such breeds with superior resilience deserves attention linked to unique attributes of their products[132].

3.3.4 Toxicity/ pollution

Negative environmental impacts of the dairy sector in Kenya include loss of vegetation through overgrazing of natural pastures as extensive grazing is mostly practiced in the Rift Valley region, uptake of more intensive dairy production across ecosystems in the country is contributing to changes in land use, with more land needed to produce feed for dairy cows. Another issue is surface water pollution from bulking and processing activities[133]

3.3.5 Food loss and waste

Food-related hazards are expected to impact the safety of raw milk and dairy products. The safety of raw milk is also indirectly affected by farmer's practices such as poor feed storage, on-farm hygienic conditions (i.e., milking equipment and barn) and animal husbandry[134]. Microbial growth can alter the safety of raw milk during its transportation to the dairy factory, thus, food safety controls take place at the entrance of the factory to avoid microbial contamination. Pre-processing treatments (i.e., filtration and thermalization) are treatments usually used before starting the main processing treatments (i.e., separation and pasteurization) that help in the removal of some microorganisms presented in the raw milk. After separation of cream from skimmed milk, both are pasteurized to remove or reduce pathogens at acceptable levels. However, some microbial hazards, can survive thermal treatments and contaminate dairy products[135].

In addition, the safety of dairy products is expected to be compromised by the presence of on-farm food-related hazards such as mycotoxins, which directly impact dairy products through contamination of cow's feedstuff, and which might be even more important under climate change conditions[136] The by-product of biogas acts as a sustainable consumption and production practice. It can help reduce the prevalence of infectious diseases and reduce methane production. This sustainable consumption and production practice is also a source of fertilizer for farming, thus reducing the use of synthetic fertilizer. The biogas produced is a source of energy for cooking and water heating[137].

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[132] Mwai, O., O. Hanotte, Y. Kwon, and S. Cho. 2015. African indigenous cattle: Unique genetic resources in a rapidly changing world. Asian-Australasian Journal of Animal Sciences 28 (7), 911–21. Available at: doi:10.5713/ajas.15.0002R

[133] Muriuki, H.G. 2011. Dairy development in Kenya. Rome: FAO.

[134] Guzmán-Luna, P., Mauricio-Iglesias, M., Flysjö, A., & Hospido, A. (2021). Analysing the interaction between the dairy sector and climate change from a life cycle perspective: a review. *Trends in Food Science & Technology*.

[135] Misiou, O., & Koutsoumanis, K. (2021). Climate change and its implications for food safety and spoilage. Trends in Food Science and Technology.

[136] Chhaya, R., & Cummis, E. (2021). Feed to fork risk assessment of mycotoxins under climate change influences - Recent developments (manuscript). Trends in Food 848 Science and Technology.

[137] Kwamboka, E., Nyambane, A., Ogeya, M., Takama, T., & Diaz-Chavez, R. A. (2022). Transforming Kenya's dairy industry through sustainable consumption and production practices.

3.4 SWOT Analysis

A Swot Analysis of the Dairy Sector in Kenya

Source [138]

	Strengths	Weaknesses	Opportunities	Threats
Economic Robustness	Relatively well-established sector with diverse input and services markets Diverse financial services (banks, MFIs, SACCOs) offering agriculture (dairy farming) financial products Strong history of keeping cattle; large livestock population with availability of quality dairy genetics Widespread market distribution network for milk and dairy products Growth in formal processors with incentives for milk suppliers	High cost of production; low milk quality; high milk losses; high consumer prices Low overall value addition due to ¾ of milk sold raw Poor access to and quality of inputs and services (feeds, AI, extension equipment, etc.) DVC fragmentation and low supplier loyalty Low bargaining power of smallholders Processor oligopoly Few appropriate financial products for dairy sector (rigid conditions and high interest) Limited data availability and poor record keeping in the sector; accusations of unethical practices by feed suppliers and milk traders Weak governance and management capacity of DFCS to operate effectively	Growth in commercial and on-farm fodder production and conservation, fodder contracting services and feed rationing at farm level Increased demand for, and improved, services (AI and animal genetics, animal health, heifers, vaccines, drugs) Provision of embedded services by DFCSs to reduce side-selling Combining insurance with credit packages to reduce risks for banks/MFIs and enhance access to finance Growing domestic and regional markets Growing demand for diverse dairy products and expanding possibilities in value addition attracting investors Entry of young farmers willing to commercialize dairy (inheriting or leasing land) Large tracts of land available in some regions for medium- and large-scale dairy farms (from 50 to 5,000 acres) Use of ICT options to enhance data collection and record keeping Exploration for QBMPS and feed quality testing Many counties	Decreasing farm sizes Public concerns with milk quality (aflatoxin, antibiotics, microbial) High fodder and animal disease and zoonoses incidence (ECF, FMD, TB, brucellosis) Road infrastructure, transport facilities not up to par in all areas, high cost of power Environmental degradation and climate change impacts (e.g. increased risk of disease outbreaks) Danger of market distortions through donor investments Cheap milk imports from Uganda threaten market for domestic milk Poor quality feed resources imported from neighboring countries Low attractiveness of sector for foreign input suppliers Protectionist policy (Taxes for milk imports from non-EAC countries)

[138] Corné J. Rademaker, Bockline Omedo Bebe, Jan van der Lee, Catherine Kilelu and Charles Tonui, 2016. Sustainable growth of the Kenyan dairy sector; A quick scan of robustness, reliability and resilience. Report 3R Kenya/WLR 979.

			have prioritized dairy sector development with big plans for investment	
Environmental Robustness	Mixed farming systems with integrated farming practices availability of compost, manure and nutrient recycling Favourable agro-climatic conditions for dairy production	Limited awareness about environmental impact of dairy production and processing Limited attention to reduction of greenhouse gas emissions	Promote green energy, e.g., biogas from dairy manure and wastewater Promote organic fertilizer Use Increase support for mitigation in dairy sector through development of dairy national appropriate mitigation actions	Environmental degradation and climate change impacts; erosion. increasing manure management issues in landless farms Loss of indigenous breeds Invasive weeds threatening fodder production
Social Robustness	Key livelihood activity (direct/ indirect) for many households DFCS and farmer group development contributes to sense of ownership, trust and broader community development Tradition of livestock (cattle) keeping	Low attraction of farming for youth. poor access to production factors for youth and women Poor negotiation position of smallholder producers Insufficient entrepreneurial approach, with inadequate dairy farming practices	Expanding school milk program with public and private actors New employment opportunities for various groups along the DVC (e.g. transporters, service providers, traders)	Lack of interest in investing in smallholder farming Increased subsidization keeps smallholders uncompetitive, reducing their options to transition to commercial farming or changing livelihoods High zoonosis incidence and poor milk quality threatens public health

4 Recommendations

4.1 Key recommendation for value chain improvement

Cash flow

The main issue for smallholders is their cash flow. Income from selling 3-5 liters of milk per day is too low to provide cash needed for investment. In addition, this income is normally used to cover daily expenses and is not invested in dairy production. It is crucial that feeding and cattle management advice incorporates this cash constraint. Project should develop low-cost methods to increase production, for example adding cut grass, growing Napier grass, using homemade silage etc.

Animal feeding

Smallholders are very much exposed to seasonality. Some of the seasonality may be removed just by instituting good feeding planning practices where forage is bought at a low price when it is abundant and used during the dry season when its price is high, and pasture is not available. Farmers' knowledge of animal's feeds should be improved since rising costs of commercial feeds drive the cost of production up.

There is a high level of taxation for yogurt processing versus other forms of processing. The project could work with KDB on establishing neutral taxation policy.

Cooling plants

Milk production is often remote from markets and processing facilities and milk cooling centers (MCC) preserve the quality through chilling and hygienic storage. In Kenya, the poor cold chain is a recognized problem for the dairy sector. Cold chain is non-existent in the informal dairy market, and even in the formal market some milk is not cooled until it reaches a processing plant. Cooling at farm level is rare, since most farmers lack reliably electricity access and refrigerators require a sizeable upfront investment. Village collection centers generally lack cooling equipment. The ones issued by the government are no longer functional or are not connected to the grid. Strengthening the governance and managerial capabilities of cooling plant operators and fostering public-private partnerships to establish more centers is crucial.

Transport cost

Due to lack of volume the cost of transportation is high, and due to high barriers to entry there are also high mark-ups for certain types of transport. Chilling plants should actively manage the cost of transport of their members. This will reduce the overall cost in the value chain and maximize profits for producers. The actual ways of managing the cost of transport will have to be determined case by case, depending primarily on the distance from farmers to the chilling plant, their accessibility and whether they are clustered in the same area or dispersed. The geographical location of farmers should also serve as one of the guiding principles when deciding on the location of new chilling plants.

4.2 Key recommendations for value chain development actors

Commercial dairy feeds and other inputs should be subsidized to encourage farmers to supplement animals according to weight and level of production using dairy meals.

Reduce barriers in access to credit to address the high interest rates and collateral requirements; support financial packages that combine insurance with credit; encourage borrowing in collectives.

Develop joint regional investment promotion strategies to increase the region's capacity to produce dairy products for export.

Improve equitable participation of women, men, and youth in the opportunities offered by dairy production and marketing businesses by targeting existing or emerging dairy POs as crucial actors in the value chain that provide newer, promising spaces for local dairying households and communities.

To help avoid duplication of efforts, the government, regulatory agencies, and dairy sector stakeholders should create forums with all stakeholder representatives.

Prioritize facilitating regional trade and exports from the region, given the binding constraint of weak domestic ability to pay for higher value
products.
Increase cooperation between public and private parties, as well as the connections between them and global development initiatives.

Government to consider providing agricultural subsidies to farmers and removing VAT for added-value products, and to review the taxation of milk processing inputs.

Farmers should receive more ongoing training on fodder production, fodder conservation, and the use of alternative feeds from extension service providers, farmer cooperatives, and the government.

Dairy industry players should increase domestic milk production to reduce reliance on imports.

Dairy farmers develop small milk collection points to minimize the cost of transportation.