Sustainable intensification pathways for dairy farming in Kenya

A case study for PROIntensAfrica
WP2, Deliverable 2.3

Jan van der Lee, Bockline Omedo Bebe and Simon Oosting

WAGENINGEN
UNIVERSITY & RESEARCH

Sustainable intensification pathways for dairy farming in Kenya

A case study for PROIntensAfrica
WP2, Deliverable 2.3

Jan van der Lee[1], Bockline Omedo Bebe[2], and Simon Oosting[3]

1 Wageningen Livestock Research

2 Egerton University, Department of Animal Sciences

3 Wageningen University, Department of Animal Sciences

This research was conducted by Wageningen Livestock Research and partners, commissioned and funded by the Ministry of Economic Affairs (Kennisbasis program "Global Food & Nutrition Security", project "Resilience of dairy production in East Africa") and the European Commission (PROIntensAfrica project - Towards a long-term Africa-EU partnership to raise sustainable food and nutrition security in Africa).

Wageningen Livestock Research
Wageningen, October 2016

Report 997

Towards a long-term Africa-EU partnership to raise sustainable food and nutrition security in Africa

van der Lee, Jan, Bockline Omedo Bebe, and Simon Oosting, 2016. Sustainable intensification pathways for dairy farming in Kenya; A case study for PROIntensAfrica. Wageningen, Wageningen University and Research, Wageningen Livestock Research Report 997

Abstract
Using the case of the dairy sector in Kenya, this report illustrates how intensification takes shape within a given context – a context with various opportunities and constraints within which farmers have to make strategic management decisions on the future of their farms – and how sustainable this intensification is. It identifies sustainable intensification pathways for four of the most prominent dairy systems in Kenya. It takes the triple-P perspective of the Montpellier Panel definition of sustainable intensification as starting point: “producing more food with less impact on the environment, intensifying food production while ensuring the natural resource base on which agriculture depends is sustained, and indeed improved, for future generations” (Montpellier Panel, 2013). This case study then informs research needs for sustainable intensification of (dairy) farming in Africa.

This report can be downloaded for free at http://dx.doi.org/10.18174/401333
or at www.wur.nl/livestock-research (under Wageningen Livestock Research publications).

P.O. Box 338, 6700 AH Wageningen, The Netherlands, T +31 (0)317 48 39 53,
E info.livestockresearch@wur.nl, www.wur.nl/livestock-research. Wageningen Livestock Research is part of Wageningen University & Research.

Wageningen Livestock Research Report 997

Table of contents

Shortened forms and definitions

3R	robust, reliable and resilient
AECF	Africa Enterprise Challenge Fund
AI	artificial insemination
AKEFEMA	Association of Kenyan Feed Manufacturers
CBE	collection and bulking enterprise, governed by a DFCS or a private entity
CFP	commercial fodder producer
COMESA	Common Market for Eastern and Southern Africa
DFCS	dairy farmers cooperative society
DVC	dairy value chain
EAC	East African Community
EADD	East Africa Dairy Development program, 2008–16, Heifer International and partners
ECF	East Coast Fever
GDP	gross domestic product
GoK	Government of Kenya
ICIPE	International Centre of Insect Physiology and Ecology
ICT	information and communication technology
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
KALRO	Kenya Agriculture and Livestock Research Organization
KAGRC	Kenya Animal Genetics Resource Centre
KDB	Kenya Dairy Board
KeBS	Kenya Bureau of Standards
KES	Kenyan Shilling
KMDP	Kenya Market-led Dairy Program, SNV, 2012–19
MCDFCU	Meru Central Dairy Farmers Cooperative Union
MFI	microfinance institute
MoALF	Ministry of Agriculture, Livestock and Fisheries
New KCC	New Kenya Cooperative Creameries
NGO	non-government organization
NMCS	Nyala Multi-Purpose Cooperative Society
PDTC	practical dairy training centre
PPP	public-private partnership
PUM	senior export program from the Netherlands
QA	quality assurance
QBMPS	quality-based milk payment system
SACCO	savings and credit cooperative
SDCP	Smallholder Dairy Commercialization Program, MoALF and IFAD, 2006–2015
SNV	SNV Netherlands Development Organization
SWOT	strengths, weaknesses, opportunities and threats: analysis tool
T&E	training and extension
USAID	United States Agency for International Development
VAT	value added tax
WEF	Women Enterprise Fund

Glossary

3R Kenya project	As part of the Dutch transition strategy from aid to trade in Kenya, Wageningen UR in partnership with Kenyan research institutions implements a project that assesses and validates lessons learned from the Netherlands Embassy's Food & Nutrition Security programme and other related programmes that support competitive market-led agricultural development. The 3R (robust, reliable and resilient agrifood sectors) Kenya from Aid to Sustainable Trade project investigates whether the lessons from the aid era can be transferred and scaled up in the coming trade era. 3R Kenya focuses on the aquaculture, dairy and horticulture sectors.
Innovation platform	"A multi-actor configuration deliberately set up to facilitate and undertake various activities around identified agricultural innovation challenges and opportunities, at different levels in agricultural systems" (Kilelu et al., 2013)
Robust	Systematic interactions between agents that enable them to adjust to uncertainties within the boundaries of their initial configuration
Reliable	The ability of a system or component to perform its required functions under changing conditions for a specified period of time
Resilient	Dynamic adaptive capacities that enable agents and systems to adequately respond to changing circumstances
Supply chain	The links that connect inputs to farm and then on to storage, processing, transport and distribution to consumers for a given product through a single chain (Wiggins and Keats, 2013)
Value chain	The value chain may consist of several supply chains for a particular product. It includes the supporting services that allow the supply chains to operate. It may even be taken to include the factors in the economic environment as well (Wiggins and Keats, 2013).

1 USD ≈ 100 KES

Summary

The growth of the Kenyan dairy industry is private sector–led with participation of a large population of smallholder farmers and small traders linked in the value chain. The expanding formal milk market is increasingly demanding high quality milk delivered at low transaction costs from these smallholders. Therefore, these smallholders will have to make strategic decisions to invest in external inputs given the fact that they operate on a small scale, their farm sizes are decreasing and produce insufficient feed resources, and the herds are one to three cows small with long calving intervals and low milk yields, about 5 to 7 litres a day. Viewed from the concept of sustainable intensification advanced by the Montpellier Panel (Montpellier Panel, 2013), smallholder dairy farmers are under pressure to produce more milk with more efficient resource use and less impact on the environment, intensifying food production while ensuring the natural resource base on which agriculture depends is sustained, and indeed improved, for future generations. We note that this implies a *people-planet-profit* sustainability perspective, with the need to meet the demands for economic, social and economic robustness.

This study focuses on dairy farming as production locus, as well as its connections to the input- and output-side: How can the opportunities in the dairy sector be captured and how can its challenges and weaknesses be countered as to make intensification of dairy farming in Kenya sustainable?

This case study on dairy farming in Kenya aims to identify sustainable intensification pathways for Kenyan dairy farming systems by: 1) *Identifying key sustainability concerns* that sustainable intensification pathways have to deal with, by looking at dairy farming through five lenses: the farming system, the value chain, and economic, socio-political, and environmental drivers and trends; 2) *Reviewing intensification trends* in the dairy sector in order to identify promising directions and possible sustainable intensification pathways; 3) *Defining research needs* for sustainable intensification of the dairy sector.

The analysis in this report builds on a broader sector scan by the 3R Kenya project on sustainable development potential of the Kenyan dairy sector (Rademaker et al., 2016a), that looked at the triple-P sustainability of the dairy value chain, institutional governance, and the innovation support system. The present study then analysed the results of the 3R study from a farming system perspective, selecting those data relevant to the objective. Additionally, a literature review was carried out, primarily on farming system diversity and sustainable intensification pathways in the country.

The analysis can be characterized as a systems approach, in which the farming system itself is analysed, as well as its interactions with the dairy value chain as input- and output marketing system and with the bio-physical, economic and socio-political context in which it operates. Moreover, stakeholder participation – i.e. input from sector actors - has been actively pursued through interviews and through a stakeholder consultation workshop.

In assessing sustainability issues, the present study follows a bottom-up identification of sustainability indicators and sustainable intensification pathways. These are generated from interviews, augmented form literature, and structured in the MESMIS framework as described by (Astier et al., 2011).

Dairy production system typology

The suggested typology for the various dairy farming systems in Kenya for assessment of sustainable intensification pathways starts from the division between "mixed crop-livestock rainfed" and "solely livestock" systems as identified by (Seré et al., 1995), further divides these in large-scale and smallholder, and combines these with (Bebe et al., 2002)'s division of low-, medium-, and high intensity dairy farming systems as a result of land scarcity, market access and external input use. Large differences in intensification are visible, with a variety of farming systems as a result. Four of the most prominent farming systems are described, i.e. highland Kiambu county close to Nairobi, the Rift Valley (milk surplus area), Western Kenya (milk deficit area) and the coastal lowlands (milk deficit sub-humid drylands).

SWOT analysis
The key strengths, weaknesses, opportunities and constraints for Kenyan dairy farming are summarized in a SWOT. Dairy is experiencing a strong growth in demand for milk, which offers many opportunities that can translate into new investments and inclusive value chain development. Opportunities for farmers lie in increasing productivity by entrepreneurial dairy farm management linked to effective delivery of inputs and services and buffering of seasonality in feed and milk supply. Marketing opportunities for farmers lie in lowering milk production costs and improving milk quality in order to access the growing domestic milk processing capacity and the regional free trade markets.

However, for dairy farming to intensify sustainably, much more is needed than reacting to market opportunities. The scarcity of farmland is a key driver for the ongoing intensification and for this to continue in a sustainable way, production efficiency in the farming system has to increase, along with enhanced efficiency along the DVC. The latter requires integration*, improved linkages and trustworthy interactions* between farmers and other supply chain actors to *reduce high transaction costs* and strive to *improve on milk quality and safety* issues. Better DVC integration dovetails with *dependable regulatory, policy and innovation support systems. This* ensures dynamic innovation of the sector through responsive research, farm advise and education, facilitation of stakeholder innovation platforms and fostering of individual innovations.

Widening the discussion beyond economic robustness towards social and environmental robustness attracts opportunities to evaluate other pressing issues, such as inclusive development of the sector, food safety, and reduction of environmental impacts. While attention for some social robustness indicators is strong – such as inclusiveness of smallholders and youth, and gender equity – attention for other social and environmental robustness indicators is minimal, such as viability of smallholder livelihoods, farm biosecurity, animal welfare, agrobiodiversity, water pollution, packaging waste, manure handling and greenhouse gas emissions. Scores for social robustness indicators are weak in product quality and safety, with high public health risks from zoonoses, antibiotics, aflatoxin, heavy metals and other hazardous substances in milking, feeding and health practices. This is strongly related to the low levels of farmer skills resulting from two decades of disinvestment in training and extension following the Structural Adjustment Programs in the early nineties (Makoni et al., 2014).

While the GoK policy ambition for the sector, embodied in the *Kenya National Dairy Master Plan*, is to increase the share of the formal processed chain in the milk market and to improve milk quality, little headway has been made. The market share of the formal sector remains under 30% following the strong domestic market for raw milk (chilled and unchilled chains) sustained by consumer preferences, consumer purchasing power and insufficient price and quality advantages of processed milk. The latter is a prime cause for inhibited growth of exports as well.

Sustainable intensification pathways
The SWOT elements provide insights into the drivers and barriers for sustainable intensification (SI), as they describe the opportunities that farmers could capture (or already are doing so) and the challenges that they face (or that already have affected their farming systems). It is clear that the opportunities for the dairy sector drive intensification, as evidenced by the ongoing intensification. It is also clear that the threats and challenges that farmers face dampen the intensification process or cause it to occur in unsustainable ways.

Land appears to be the most limiting production factor in the Kenyan highlands, while climate effects on production are most limiting in the coastal lowlands. The scarcity of land drives up land and feed costs and restricts purchasing of land. For dairy to have sufficient comparative advantage, the productivity per hectare (return on investment) has to increase and has to be higher than for other crops and livestock – cash crops like potatoes, tea and coffee in rural areas, and horticulture and poultry in peri-urban areas. Intensification of agriculture thus means increasing the productivity of land and returns on external inputs costs, resulting in a change of land use and external input use (Dugué et al., 2011).

Intensification also shows the co-limiting character of other factors, which relate to access to:

1. Reliable provision of inputs & services including feed, AI and breeding services, veterinary. services, and extension/advisory services, for which proximity to the urban centres is a key cause.
2. Reliable output markets, which includes attractive and stable prices, and high trust relationships between farmers and milk buyers.

3. Other production factors including skilled labour (with entrepreneurial, managerial, and technical skills), public infrastructure (roads, electricity, ICT) and capital (Bebe et al., 2002); ILRI, 2008; (Udo et al., 2011).

Failure of adequate improvements in these co-limiting factors will result in unsustainable intensification, evidenced by poor scores on sustainability indicators outlined above. In extreme cases, it will totally hamper intensification, with dairy remaining on low input-low output level, being farmers' best coping strategy or best resilience strategy. Limitations in these factors are being addressed to a certain extent by bundling of inputs and services by cooperative societies and processors and by privatization of input and service supply including training and advisory services, and ongoing subsidization of cold chain equipment.

Currently farmers choose between three intensification pathways: Connecting to the processed dairy supply chain, to niche chains for quality products, or to the local raw milk chain. The choice for particular (alternative) pathways depends on the goals one wants to pursue, and on how one deals with the trade-offs between alternative pathways and coping strategies, notably between *people-planet-profit* objectives. Focus on either of these three would result in the following:

Economic robustness **–** Reduction in cost of production and focus on entrepreneurial dairy farmers would result in scale enlargement of farms and exclusion of non-entrepreneurial smallholder farmers.

Social robustness **–** Focus on smallholder inclusion for food security, rural employment and livelihoods, with development of cooperative societies and addressing of inefficiencies in the chain, would have to deal with the tension between "development for all members" and "relevant services to the high producing members". Investments should focus on ways to market milk locally and/or with cottage type industries, rather than competition in the bulk milk sector with the larger processors.

Climate-smartness **–** Focus on nutrient balance would favour local systems vs. traded feed and fodder, as well as good dairy farming practices on manure management, energy efficiency and use of renewable energy.

As outlined above, large differences in intensification are visible, with a variety of farming systems as a result. We show how farmers at different intensification levels can - or should – have different strategies for sustainable intensification, depending on their current land use intensity, access to external inputs and services, and the markets they trade in. We explore patterns within the four selected farming systems. To do so, the outcomes of the SWOT analysis inform coping strategy options, to deal with the major threats, risks, stresses and shocks that dairy farming is susceptible to. For farming systems at different intensification levels we explore strategies for sustainable intensification (SI), identifying key SI challenges, key SI choices that farmers have to make, and the inter-connected coping strategies farmers could employ. These coping strategies are not a menu to pick from, but mutually dependent interventions. In strategy selection, trade-offs between economic, social and environmental sustainability parameters can make for big differences. Key parameters include 'reducing cost of production' vs. 'retaining the smallholder mode of production'; 'smallholder inclusion for food security, rural employment and livelihoods' and "development for all members of cooperative societies" vs. 'focus on entrepreneurial dairy farmers'; 'participating in the bulk processed milk sector' vs. 'developing ways to market milk locally'; 'local nutrient-balanced systems' vs. 'traded feed and fodder with accumulation of manure'.

To assess and monitor SI pathways for dairy in Kenya, we start with the seven attributes of sustainable systems as listed for the MESMIS framework by (Astier et al., 2011). We relate the indicators that have surfaced throughout this report to these seven attributes.

In conclusion, the present case study identifies the research needs on SI pathways for dairy farming in Kenya. These research needs may inform other contexts as well. They are structured using the same five lenses used in the analysis, and address a number of key areas defined in the PIA literature review (PROIntensAfrica, 2016):

- For farming systems, research needs include the importance of proper sustainability indicators for the assessment of triple-P robustness of dairy farming systems at different intensification levels, for different intensification pathways, and for the DVC at large; empirical assessment of trade-offs in intensification of land use; quantification of yield gaps and design of promising interventions to address it; evaluation of fodder options and genetics from the perspective of improved reproduction and reduced seasonality of production and costs of production; on-farm biosecurity, animal welfare and health care.

- Value chain research needs to include evaluation of models for input and service provision, for improving loyalty and trust in the processed milk supply chain, quality assurance models and compliance, ways to increase value chain competitiveness, ways to shape and strengthen public–private partnerships for AI, breeding and/or veterinary service delivery; institutionalization of sector-wide innovation platforms; and innovative financing mechanisms.
- Research needs on sustainability issues include:
    - For economic sustainability: assessing ways to significantly reduce cost of production; profitability of collection and bulking enterprises; efficacy of different commercial fodder production business models; governance mechanisms and management practices in dairy cooperative societies; and evaluate quality assurance systems for feeds and fodders;
    - For social sustainability: review coherence of public policies and governance arrangements; assess implications of compliance with milk quality standards and statutory revenue payments; explore inclusive development approaches on support to food and nutrition security and poverty alleviation; consider whether private companies can support inclusiveness; quantify cost of production and farm profitability for diverse smallholder farm sizes and farming styles; identify pathways to significantly improve quality of processed milk; assess impact of milk and feed quality assurance systems on product safety; evaluate effectiveness of novel training and extension interventions;

For environmental sustainability: environmental impact assessment of dairy practices; evaluate nutrient balances for different farming systems, fodder interventions, and manure management innovations for land-scarce farms.

1 Introduction

1.1 Problem statement – how sustainable is the growth of the dairy sector in Kenya?

Kenya has a vibrant dairy industry that contributes 14% of the agricultural gross domestic product (GDP), 40% of the livestock sector GDP and 4% of the national GDP. The industry is currently growing at an average rate of 5–7% per year. There are over 1.8 million smallholder milk-producing households who own one to three cows, which in aggregate own over 80% of the national dairy herd. The cattle population estimates vary from 4.2 to 6.7 million heads, depending on methodology used (KDB, 2015); ILRI, 2008). Milk yields attained depend on the scale of production, with small-scale producers recording about 5–8 litres per cow per day and large-scale farmers recording 17–19 litres per cow per day (ACET, 2015). (KDB, 2015) mentions a number of 1.2 million citizens being employed in the sector, but this figure seems an underestimation, as the number of dairy farmers already exceeds 1.8 million.

The growth estimates since 2000 do reflect the economic vibrancy of the sector as shown in the growth of domestic milk production, processing capacity, per capita milk consumption, and exports (ILRI, 2008; (KDB, 2015) (Makoni et al., 2014). Between 2003 and 2012, total milk production grew at an average of 5.3% per year, from 3.2 to 5.2 billion litres (see **Figure 1.1**).

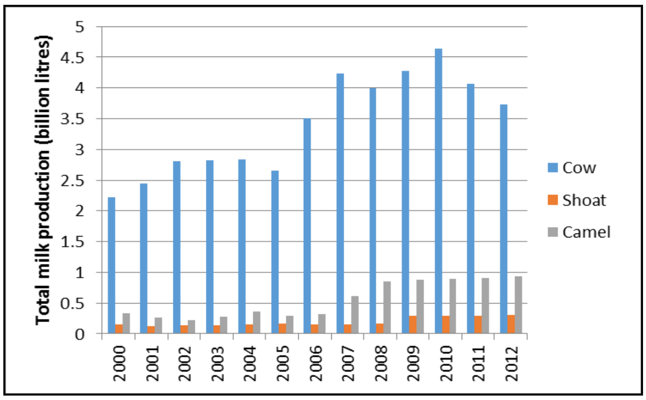

Figure 1.1*Total milk production trends all species*
Source: KDB n.d.

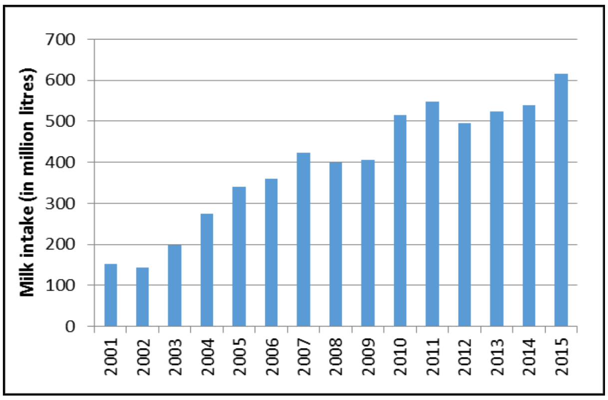

Figure 1.2 *Trend of annual milk intake formal sector*
Source: KDB n.d.

The annual per capita milk consumption in Kenya is estimated at 110 litres, the highest in sub-Saharan Africa. This is the equivalent of 5.2 billion litres a year and is a reflection of the growing demand for milk and value added dairy products, owing to strong traditions of including milk in diets, expanding urbanization, a rising middle class and export opportunities in the region. In response to consumption growth estimated at 5.8% annually, the Kenya National Dairy Master Plan has a strategic objective to stimulate annual per capita milk consumption to 220 litres by 2030 (MoALF, 2010a; RoK, 2007). To match this consumption growth, the Master plan defines strategic actions to increase productivity and competitiveness, efficient service delivery, policy reforms, and mainstreaming of attention for gender, food security, climate change and natural resource conservation in dairy production and marketing.

Marketed milk amounts to 55% of the total production (45% is home-consumed or fed to calves (Muriuki et al., 2003). The bulk of the marketed milk (~70%) is sold as unchilled or chilled raw fresh milk directly to consumers through informal market channels. These channels are characterized by non-compliance with the regulated safety and quality standards and collection of statutory revenues (taxes, cess, levies, VAT) (KDB, 2015). The formal market for milk of cows has witnessed steady growth over the years, with milk intake growing at an average of 7% per year, from 153 million litres in 2001 to about 616 million litres in 2015, being 12% of the estimated production (KDB n.d.) (see

Figure 1.2), but with a marked seasonality of between 11 million and 16.5 million litres in monthly variations in the 2010 - 2015 period. This growth is attracting both domestic and international private investors seeking to seize business opportunities in the domestic and export markets (Business Daily, 2016). Export opportunities are mainly in the Eastern and Southern African region (Reardon et al., 2015). In 2014, exported milk and dairy products were worth KES 1 billion (KDB, 2015).

The dairy industry is regulated by the Kenya Dairy Board (KDB), mandated "to regulate, develop and promote the dairy industry in Kenya". The regulatory roles are in licensing, inspections and surveillance and certification of locally marketed, exported and imported milk to assure consumer safety from physical, biological, chemical or adulteration hazards. KDB's promotional role is to enhance consumption of milk and dairy products among Kenyans.

The authorities have defined strategic actions in the *Kenya National Dairy Master Plan*, anchored on a vision of becoming a globally competitive milk production sector, envisaged to push a shift from informal to formal supply chains (MoALF, 2010a). There are multiple objectives in this push, including reducing market share of low quality liquid milk, encouraging progressive investments in the development of the dairy industry and assuring public health for consumers, while in the process creating skilled jobs and earning revenues for public expenditures (MoALF, 2010a). Improving milk quality by increasing the percentage of processed milk is the most emphasized objective in the dairy master plan (MoALF, 2010a); (MoALF, 2010b). However, studies by the International Livestock Research Institute (ILRI) have demonstrated that scores for quality indicators are as poor for formal traded pasteurized milk as they are for the informal traded raw milk (Omore et al., 2005) and that quality deteriorates from the farm milk can to the tanker (Ndungu et al., 2016).

The growth of the Kenyan dairy industry is private sector–led with participation of a large population of smallholder farmers and small traders linked in the value chain. The expanding formal milk market is increasingly demanding high quality milk delivered at low transaction costs from these smallholders. Therefore, they will have to make strategic management decisions to invest in external inputs given the fact that they operate small and declining farms with insufficient feed resource that support small herds with low productivity levels. Viewed from the concept of sustainable intensification advanced by the (Montpellier Panel, 2013), smallholder dairy farmers are under pressure to produce more milk with more efficient resource use and with less impact on the environment, to ensure the natural resource base on which dairying depends, at the same time meeting the demands for economic, social and economic robustness.

This study focuses on dairy farming as the production locus, including its connections to the input- and output-side. How can the opportunities in the dairy sector be captured and how can its challenges and weaknesses be countered as to make intensification of dairy farming in Kenya sustainable?

1.2 Objectives of this case study

This case study on dairy farming in Kenya aims to identify sustainable intensification pathways for Kenyan dairy farming systems by:

1. Identifying key sustainability concerns that sustainable intensification pathways have to deal with, by looking at dairy farming through five lenses (see **Figure 1.3**): the farming system, the value chain, and economic, socio-political, and bio-physical drivers and trends (Chapter 2).
2. Reviewing intensification trends in the dairy sector in order to identify promising directions and possible sustainable intensification pathways (Chapter 3).
3. Defining the research needs for sustainable intensification of the dairy sector (Chapter 4).

1.3 Methodology used

The analysis in this report builds on a broader sector scan by the 3R Kenya project on sustainable development potential of the Kenyan dairy sector (Rademaker et al., 2016a), that looked at the *people-planet-profit* sustainability of the dairy value chain (DVC), institutional governance, and innovation support system.

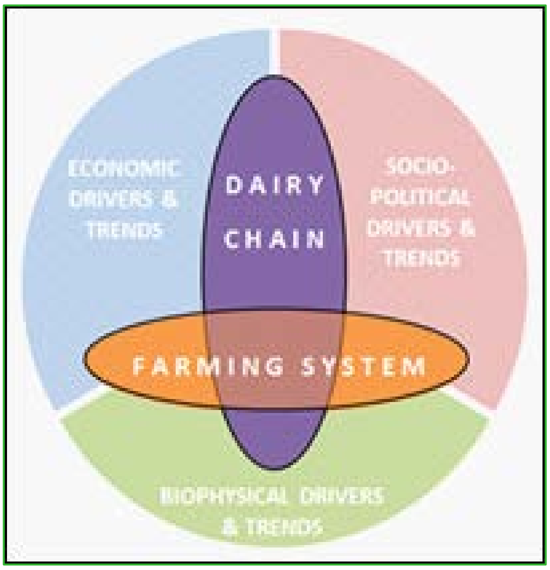

Figure 1.3. *Five lenses for analysis of dairy farming systems (van der Lee et al., 2014b)*

The study process consisted of:

1. A review of grey literature, supplemented with scientific literature
2. Interviews with stakeholders - Key individuals and organizations in the Kenyan dairy sector were selected using team knowledge of the sector. They were identified in such a way as to ensure inclusion of actors involved with activities along the DVC and from commercial-, government- and research- and extension-related work, while additional actors were identified during the fieldwork ('snowball sampling'). Of 26 interviews with one or more people each, eleven were with actors within the value chain (farmers, dairy societies, processors, input suppliers, and service providers) and 15 were with chain supporters (government agencies, knowledge institutes, industry associations, NGOs, consultants). Interviews were semi-structured, using open questions and a checklist. The interviews were recorded after permission to do so was granted. The interviews were transcribed using Transcription Buddy and FTR Player software, and summaries were made.
3. A validation and prioritization workshop to consult with stakeholders - An executive summary and a PowerPoint presentation summarizing a draft of the quick scan report were used as input for a stakeholder workshop held on 19–20 July 2016 in Nairobi. The stakeholders who were invited included those who were interviewed, supplemented with other key stakeholders, again based on team knowledge of sector actors. The objective of the workshop was to validate the findings from the sector scans and to identify priority issues for development and research.
4. Feedback from the workshop was used to complement the draft report (which combined results from the literature review and interviews), with the report of (Rademaker et al., 2016a) as result.
5. The results of the 3R study were then analysed from a farming perspective, selecting those data relevant to the objective of this case study. Additional literature review was carried out, primarily on farming system diversity and sustainable intensification pathways in the country, and this report was written.

The analysis can be characterized as a **systems approach**, in which the farming system itself is analysed, as well as its interactions with the DVC as input- and output marketing system and with the bio-physical, economic and socio-political context in which it operates. Moreover, **stakeholder participation** – i.e. input from sector actors - has been actively pursued through interviewing and through the stakeholder consultation workshop.

In terms of factors for sustainability, this study follows a bottom-up identification of sustainability indicators, generated from the literature and interviews, rather than top-down use of a certain assessment framework, albeit that looking at *people-profit-planet* aspects and at value chain, institutional governance and innovation support system was predetermined.

Due to the nature of the 3R Kenya, this study leans rather heavily on examples from SNV's Kenya Market-led Dairy Program (KMDP) project (SNV Kenya, 2015), with examples from other projects where appropriate.

2 Dairy farming in its context

2.1 Farming systems

Dairy farming systems in the country, viewed from a sustainable intensification perspective, are highly varied and already cover different rates of intensity. Farming systems and intensification levels are the outcome of land and population pressure, agroecological suitability, cultural traditions, government policies, dietary preferences, preference for certain cattle breeds, and access to and utilization of output, input and service markets (Bebe et al., 2002); (Muriuki and Thorpe, 2006); (Mburu et al., 2007; Omore et al., 1999).

Literature suggests various ways for a typology of dairy farming systems in the country. (Omore et al., 1999) indicate a main division between sedentary and pastoralist systems: ‘The [production] systems in agroclimatic zones (ACZ) 1-4 are mostly associated with arable farming, the systems in AGZ 5-7 are mostly pastoralist’; the majority of dairy farms is situated in ACZ 1-3[1], where there is bimodal rainfall that supports high biomass yields of natural and improved pastures and fodder production for dairy feeding. (van de Steeg et al., 2010) further add major crop objectives as distinctive factor (food/cash/export crops), defining five categories: subsistence farms with limited dairy activities, farms with major dairy activities, intensified crop farms with limited dairy activities, export cash crop farms with limited dairy activities, and export cash crop farms with major dairy activities.

Table 2.1 suggests a typology of the various dairy farming systems in Kenya for assessment of sustainable intensification pathways. It starts from the division between “mixed crop-livestock rainfed” and “solely livestock” systems as identified by (Seré et al., 1995), further divides these in large-scale and smallholder, and combines these with (Bebe et al., 2002)’s division of low-, medium-, and high intensity dairy farming systems as a result of land scarcity, market access and external input use.

KDB (2015) puts the 2014 number of smallholder milk-producing households who mostly own one to three cows (*SM* and *SL* in **Table 2.1**) at 1.8 million, which in aggregate constitutes over 80% of the national dairy herd (estimated at 4.2–6.7 million cattle). The other 20% are held by medium-and large-scale farms (*LL* and *LM*). (Omore et al., 1999) estimate that large-scale intensive (*LL-H* and *LM-H*) and semi-intensive farms (*LL-M* and *LM-M*) number five thousand, and that extensive (low-intensive) medium- and large-scale dairy farms number 45 thousand (*LM-L* and *LL-L*), compared to 625 and 660 smallholders for the same categories (*SM-HM* & *SL-HM* and *SM-L* & *SL-L* respectively). Assuming that (Omore et al., 1999) data denote the number of smallholders in 1998 and that KDB (2015) data denote the number of smallholders in 2014, the growth over a 16-year period would be 500 thousand smallholder dairy farmers, which would translate to an average annual growth of 2%. Milk yields of most smallholders (*SM-HM* and *SL-HM*) are about 5–8 litres per cow per day, while large-scale farmers (*LM-HM* and *LL-HM*) typically reach yields of 17–19 litres per cow per day (ACET, 2015).

While intensification of farms along a pathway from low to medium to high intensity does occur, the columns in **Table 2.1** do not refer to intensity levels of particular farming systems: For example, LL-L denotes large-scale dairy ranches in the Rift Valley, while LL-H denotes commercial farms with high external input levels in (peri-)urban areas across a range of environments.

[1] ACZs in Kenya: 1-humid, 2-sub-humid, 3-semi-humid, 4-semi-humid to semi-arid, 5-semi-arid, 6-arid and 7-very arid. Orodho, A.B., 2006. Country pasture/forage resource profiles. Kenya.

Table 2.1 *Dairy production systems in Kenya*

	Small-scale		Medium- and large-scale	
Farming system: / **Conditions:**	**Solely livestock SL**	**Mixed crop-livestock rainfed SM**	**Solely livestock LL**	**Mixed crop-livestock rainfed – LM**
Land scarce, good market access, high external input level	**SL-H**	**SM-H**	**LL-H**	**LM-H**
farming orientation	market	market	market	market
production focus	dairy	dairy	dairy	dairy
breed	exotic	exotic	exotic	exotic
location	(peri)urban	C, CR	(peri)-urban	CR, SR, C
feeding system	zero-grazing	zero-grazing	zero-grazing	zero-grazing
Medium land pressure, - market access and - external input level	**SL-M**	**SM-M**	**LL-M**	**LM-M**
farming orientation		livelihood-market	market	market
production focus		dairy-manure (-meat-draught)	dairy-meat	dairy-meat
breed		exotic/crosses	exotic/crosses	exotic/crosses
location		C, W, E, CR, SR, Cst	CR	CR, SR
feeding system		(semi) zero-grazing	(semi) zero-grazing	(semi) zero-grazing
Low land pressure, poor market access, low external input level	**SL-L**	**SM-L**	**LL-L**	**LM-L**
farming orientation	livelihood	livelihood	livelihood–market	livelihood–market
production focus	dairy-meat-manure	dairy-meat-manure-draught power	dairy-meat	dairy-meat
breed	Zebu	Zebu	Zebu	Zebu
location	pastoralist areas	C, W, E, Rift, Cst	NR, SR	Rift
feeding system	grazing	grazing	Grazing	grazing

Farm size →
Intensification ↑

Sources: (Bebe et al., 2002); (Njarui et al., 2016; Omore et al., 1999)
LM-H *means* ***L****arge-scale* ***M****ixed crop-livestock –* ***H****igh intensity;* ***SL-L*** *means* ***S****mall-scale, solely* ***L****ivestock –* ***L****ow intensity*
C *– Central region,* ***W*** *– Western region,* ***E*** *– Eastern region,* ***NR*** *–North Rift,* ***CR*** *– Central Rift,* ***SR*** *–South Rift*

Four cases illustrate this situation, together largely describing the variation of dairy farms in the country. **Figure 2.2** illustrated the existing differences in farm size and intensification level. Variations in farm size within regions already have been described above in general terms (small-, medium- and large-scale). Variations in intensification level do not only depend on variation in farm resources and strategies of individual farmers, but also on proximity to markets – all areas have less and more remote locations and urban centres in all ACZs tend to have more intensive (peri-)urban dairy:

- **Kiambu County** is closest to Nairobi, the major milk consumption centre in the country, with well-developed infrastructure but with small farm holdings declining in size. Good market access, bimodal rainfall and small farm holdings have driven the mixed rainfed systems (MRH[2]) in Kiambu to the highest intensification levels in the country, represented by highest adoption of zero grazing feeding system, high stocking densities, nutrient recycling and the most stable milk market. Because of fodder scarcity, non-dairy households find fodder growing for sale to dairy households an attractive enterprise, which has led to feeding innovations in fodder, pastures,

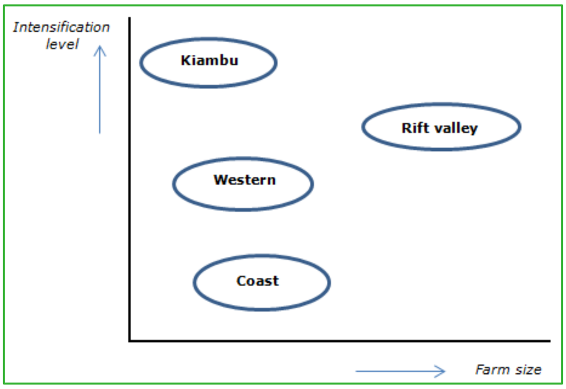

Figure 2.2 *Schematic chart for farm size and intensification level of dairy farms in four regions*

[2] *MRA: Mixed rainfed systems in arid and semi-arid tropics and subtropics*
MRH: Mixed rainfed systems in humid and subhumid tropics and subtropics
LGA: Solely livestock grassland-based system in the arid and semi-arid tropics and subtropics
LGH: Solely livestock grassland-based system in the humid and subhumid tropics and subtropics
Source: Seré and Steinfeld 1995

non-conventional feeds and agro-industrial by-products sourced externally. This raises the cost of production, but milk prices in the huge Nairobi city milk market are attractive. The production objective is thus to produce more milk, which is attained by keeping Holstein-Friesian cows and use of AI. Rearing of herd replacement is, however, a challenge, because investing in heifer rearing takes a long period without returns, as first calving age averages 30 months. The Kiambu dairy farms thus been described as "flying herds" because of sourcing replacement heifers from the Rift Valley, where there is a comparatively better developed dairy supportive infrastructure and larger herds producing surplus marketed milk, heifers and bulls (Njoroge et al., 2004); Okeyo et al., 2000; (Ongadi et al., 2007).

- **Western Kenya** is a region classified as milk deficit, where farmers typically keep one to three cows, which they source from the neighbouring milk-surplus Rift Valley region. Dairy farming is integrated with crops, mainly maize inter-cropped with beans in Upper Midland and Lower Midland agroecological zones (MRH systems[2]). Like Kiambu, Western Kenya also experiences a heifer shortage because demand surpasses supply. Breeding is characterised by herd replacement using cull cows sourced from fellow smallholder herds of the Rift Valley, but without known performance history or memorized records, and are mated with bulls of unknown progeny merit, which present challenges for attaining increased milk yield. The cattle genotypes are indigenous breeds and their crosses with dairy breeds sourced from the neighbouring Rift Valley, but on-farm fodder is inadequate for high milk producing genotypes. In response, farmers who introduce dairy genotypes practice cut-and-carry stall feeding under zero grazing system or semi zero grazing to produce milk, which attracts favourable prices because the region is deficit in milk supply.
- In the **Rift Valley**, farms are larger and so are the herds, which are grazed on paddocked pastures with limited supplementation, be it concentrates or fodder. Manure is utilised in fertilizing pastures and food crops. Many households integrate dairy with cash crops, mainly tea – systems are LGH or MRH[2]. Households hold strong cultural attachment to cattle for identity, family milk, security, accessing loans from banks, and financing household emergency cash needs (Weiler et al., 2014). Dominant cattle genotypes are Holstein-Friesian and Ayrshire cattle breeds fed on pastures and own-farm produced hay, mostly Rhodes and kikuyu grass. Use of bulls dominates over AI, like in other dairy regions of Kenya, and herd recording is not a practice to inform breeding or business decisions. Membership in farmer cooperatives is stronger in the Rift Valley as compared to Western Kenya.
- The **coastal lowlands** of Kenya have dairy production based on crossbreeds between Holstein-Friesian or Ayrshire with Brown Swiss or Jersey cattle. The region suffers high humidity and endemic trypanosomiases together with tick-borne diseases. Dairy is practiced in zero grazing units covered with nets to keep of the tsetse fly, a vector of trypanosomiases. The challenges in coastal lowland dairy production is ameliorating the high humidity effects, trypanosomiases, and feed resource scarcity matched with the climatic conditions, reflected in LGA and MRA systems[2]. In general, breakthroughs for smallholders in these challenges are apparent, but there are successful dairy ranches in the region, which are the sources of replacement stock to farmers. The feed resources are grass species adaptable to soil moisture scarcity. Milk prices are attractive because the region is milk deficit.

A lively trade exists in in-calf dairy breed heifers from the Rift Valley to other regions

2.2 Value chain developments

This section explores the place of dairy farming in the dairy value chain (DVC) in Kenya, focusing on interactions and exchanges with DVC actors on the input and output side.

The expanding sector is characterized by an increasingly sophisticated value chain with a diverse range of actors at different nodes (**Figure 2.1**). On the input node, actors include agroinput suppliers, who range from small agrovet stockists to large national and international firms, heifer production farms and numerous feed manufacturers, and various service providers offering a range of services including veterinary, animal health and breeding, training and extension, including private consultants.

At the production node, milk producers include small-, medium- and large-scale dairy farmers with a variety of farming systems, as described in **Section 2.1**.

At the marketing node there are milk collection and bulking enterprises (CBEs), which may be DFCSs, processors or government-installed facilities. There is also a range of transport services provided by dairy farmer cooperative societies (DFCSs), processors or contracted transporters. There are milk traders procuring milk from farmers to sell directly to consumers or acting as collecting agents of processors (the latter being included under "transporters" in **Figure 2.1**). Next are the processors, of which there are currently 27 active in Kenya, four of which control 85% of the milk intake (ACET, 2015). This number does not include numerous small-scale processing facilities at farm- or retail outlet level, which may consist of just a batch pasteurizer. Retailers vary in scale of operation from small neighbourhood shops to large supermarkets, and consumers are segmented into buyers of raw unchilled, raw chilled, or chilled processed milk and dairy products.

Additionally, various public research organizations, universities, training institutes and NGOs support the development of the sector: the Kenya Dairy Board (KDB [see paragraph 1.1]); the Ministry of Agriculture, Livestock and Fisheries (MoALF) plays a role in regulation and policy direction of the sector,; the Kenya Bureau of Standards (KeBS) has the mandate of assuring quality standards for milk and dairy products traded in the domestic market; the Kenya Agriculture and Livestock Research Organization (KALRO) is responsible for research and the Dairy Training Institute in Naivasha for training of midlevel technologist for the milk processing firms and cooperatives.

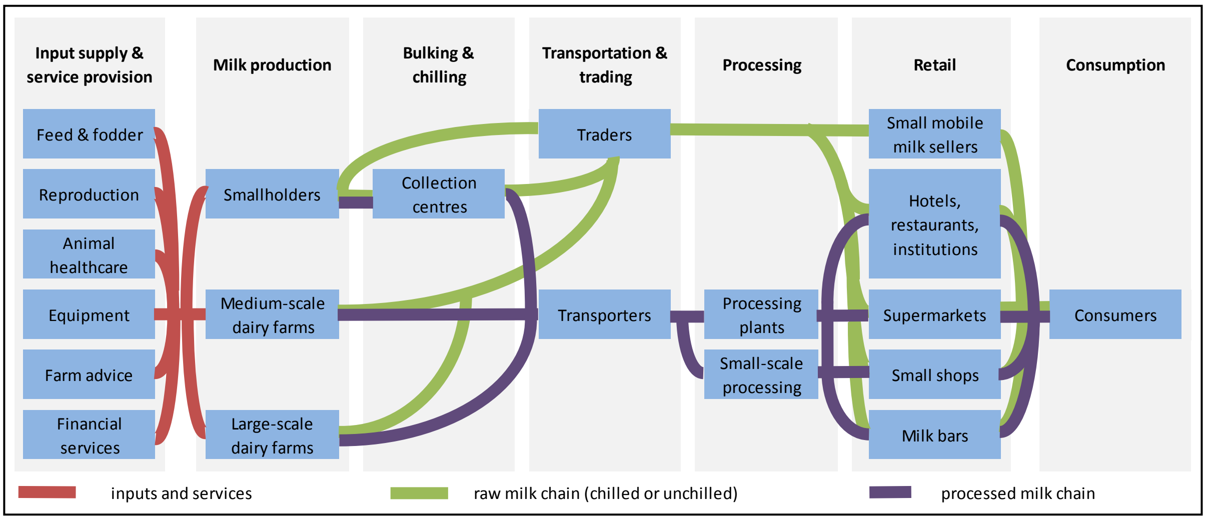

Figure 2.1 *Overview of dairy supply chains in Kenya*

The DVC 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 (cess, levies, taxes, VAT). From the farmers' point of view, at the production level, there are three distinct chains: a) unchilled, raw; b) chilled, raw; and c) chilled, processed milk. The transformation from a) and b) towards a larger formal channel is envisioned via the chilled, processed chain (c) by targeting capacity building and enabling policies, as outlined in the *Kenya National Dairy Master Plan* (MoALF, 2010ab) (see **Section 1.1**).

2.3 Economic drivers and trends

While demand developments for dairy in the country look positive due to urbanization and rapid growth of the middle class (and to a lesser extent population growth), key economic sustainability concerns include the competitiveness of the sector due to high cost of milk production, seasonality of supply with resulting price fluctuations, chain fragmentation and milk quality concerns. This paragraph explores the underlying issues, as diverse as logistic deficiencies, value chain loyalty, and consumer demand patterns.

2.3.1 Issues with access to production factors

Access to credit - 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. From the literature review and interviews (e.g. interview 4) it appears that loans from commercial banks are mainly suitable for medium- to large-scale farmers because of stringent collateral requirements, while smallholders mostly rely on credit from DVC partners and SACCOs which have favourable repayment terms. A more thorough analysis of access to and source of credits is available in (Rademaker et al., 2016a), including opportunities and challenges for credit from commercial banks, mechanisms for value chain financing, micro-financing and government-affiliated funds for vulnerable groups.

Access to land - A major threat to the dairy sector is the decreasing size of land holdings among smallholder dairy farmers who continue uptake of dairy enterprise, which occurs particularly in peri-urban areas (Makoni et al., 2014). It is a threat because it reduces the capacity to produce enough quality fodder to feed dairy cows. In response, farmers source fodder from public lands (roadside grass, dumpsites) which they supplement with alternative feeds (non-conventional feeds) and purchase of crop residues, fodder and concentrates. These practices pose health risks through contaminated feed and negatively affect cost of production. Small-scale farmers on average keep three dairy cows on 0.2–3 hectares of land devoted to dairy production (ACET, 2015; Ettema, 2015). In the Rift Valley, dairy production is less intensive; in areas such as Kitale, Eldoret and Nanyuki, large tracts of land are available, resulting in farms of 20–2,000 hectares (Makoni et al., 2014).

Access to labour - Smallholders hire casual labour for daily management of the herd, including fodder production and sourcing, herd feeding, milking, milk delivery and herd health care. The hired labour is often school drop outs without technical background on dairy management, and therefore is of low quality, hired at low wages, in most cases below the statutory minimum wage rate. A farmer may negotiate payment with the farm labourer on basis of experience. When wage rate is low, the farm benefits because a viable alternative productive engagement is lacking. With many farmers aging, the need for farm labour is increasing, to support dairy herd management routines. Presently, there are many young trained technicians that can be hired, but often they are hired at wage rates below the corresponding wage earned when in an equivalent position in the public service. If the wage laws would be enforced, youth trained and skilled in dairy herd management may find farm labour attractive, but farm labour costs will rise, with implications on the margins for farmers and the milk price for consumers (Tegemeo, 2016).

Access to infrastructure - Since 2010, Kenya has been investing heavily in improving rural infrastructures – road networks, water supply, electricity grid, and subsidized dairy bulking and processing facilities. Improved infrastructure should open milk markets and lower transaction costs.

2.3.2 Issues with input supply, service delivery and farm management

Compared to the dairy sectors in the neighbouring countries, the Kenyan dairy sector has well-developed input supply and service provision, delivered through diverse channels (Makoni et al., 2014). The most important issues in the input and service provision to dairy farms, as discussed in the next sections, are access issues of scarcity, poor quality and high prices for key inputs and services: feed and fodder, AI and breeding services, animal health services, equipment supply, and training and extension services.

2.3.2.1 Feed and fodder

Enhancing feeding systems is central to improving productivity in the sector and critical to growing a sustainable sector, particularly in light of the effects of dairy production on climate change (CCAFS, 2015). Four issues are of importance: a) fodder production, conservation and marketing; b) quality and safety of diverse feeds utilised, especially from roadsides and sewerage and non-conventional feeds (poultry waste, weeds, legume trees), c) concentrate feed supply chain issues; and d) impact of feed and fodder on cost price of milk.

Fodder production, conservation and marketing

The limited availability of land is a primary challenge for fodder production in smallholder and (peri-)urban commercial farms, necessitating intensification and commercialization of fodder production. Forages form the most important feed resource for dairy cows. Many smallholders (and some medium-scale farms) are unable to produce sufficient fodder because of their small holdings and supplement with grazing and fodder harvested from public areas (using hired casual labour) or purchased fodder obtained from traders – such as hay, silage, agro-by-products, or crop residues (Wambugu et al., 2011).

Next to natural grazing in remote areas, in the semi-rural and peri-urban areas dairy cows are fed on crop residues and on Napier grass. The latter has been the fodder resource base for dairy cow feeding; following Napier disease issues, increasingly other planted fodders are grown, both protein-rich and energy-rich forage varieties (Perfometer Solutions, 2013). These include yellow maize, sorghum, Boma Rhodes grass, Lucerne, vetch, and lupine. Improving year-round fodder availability requires availability and affordability of inputs such as high quality seed, pesticides and fodder conservation technologies. Forage seed is expensive due to high development costs and limited availability. Other challenges include yield loss due to plant diseases (Aketch, 2014; (Mulaa et al., 2004); interview 18). KALRO and the International Centre of Insect Physiology and Ecology have developed a Napier variety resistant to Smut and Stunt diseases called Ouma. KALRO is also investigating and developing alternative grasses such as Setaria spp. and Brachiaria spp. (interview 18). Finally, fodder supply is heavily dependent on rainfall, resulting in inconsistent supply. Adoption of forage conservation technologies, such as haymaking and silage production, remains limited, due to low access to equipment and limited farmer skills, despite extension and training on the need for fodder and feed budgeting (Makoni et al., 2014).

Smallscale contracted silaging of maize and napier helps reduce seasonality of production

Recent experiences indicate emerging models in commercial fodder production (see **Box 2** for KMDP experiences in this field). Medium- and large-scale farmers are turning to commercial fodder production (CFPs), selling surplus hay (Makoni et al., 2014). Some DFCSs are offering access to fodder as an embedded service to their members through a variety of methods: increasing the availability of fodder seeds in their agrovet shops, enhancing linkages to credible fodder seed suppliers, promoting on-farm fodder production by members – improving both quality and availability – and creating linkages with CFPs for supply of hay (Rademaker et al., 2016b). One example is Nyala Multi-Purpose Cooperative Society (NMCS), which sells hay mainly in the dry season when fresh grass availability is low (interview 9).

Quality and safety of feeds utilised

Faced with the feed scarcity described, farmers desperately respond to maintain their animals on alternative feed sources accessible to them. These include grass from roadsides and sewerage, non-conventional feeds such as poultry waste, weeds, and legume trees surviving drought, water and agroindustrial by-products including rejected cereals. The challenge is in safety and quality of these alternative feeds for cows and human consuming the milk and meat from cows fed such feeds. There is the risk of contamination with heavy metals, parasitic and microbial residues, and toxins. In addition, farmers access these feeds at a cost while the health risks associated with them could be a source of increased loss to farmers.

Concentrate feed supply chain issues

The provision of concentrates for supplementary feeding of dairy cows is pivotal if milk production is to be increased. Input suppliers such as Sidai Africa Ltd sell mostly to smallholders, as medium- and large-scale farmers prefer to produce their feed on-farm to overcome quality and cost constraints (interview 6). The concentrate feed supply chain in Kenya faces a number of key bottlenecks, including low and variable quality of concentrates; reliance on imported feed ingredients of uncertain quality; and rampant trade malpractices in the feed industry (ACET, 2015); (ABS/TCM, 2013); (PPD Consultants, 2013); (MoALF, 2010a). These bottlenecks are attributed to:

1. *Variability in access to and quality of key inputs for feed manufacturing* – this is due to use of substandard raw materials by feed millers following scarcity of by-products (MoALF, 2010a; PPD Consultants, 2013).
2. *Mixing of commercially produced feeds with lower quality ingredients* – traders produce cheaper concentrates to meet farmer demand for cheaper feeds (interview 6; ACET, 2015).
3. *Absence of a functioning feed quality assurance (QA) system* – enforcement of quality standards is weak and does not address other systemic feed quality issues, such as aflatoxin contamination. Various feed manufacturing companies, such as Unga, are implementing stringent measures to ensure they use quality ingredients (e.g. screening maize for aflatoxins).
4. *High prices of concentrates* – the Association of Kenyan Feed Manufacturers (AKEFEMA) attributes high cost of concentrates to the low feed-mill capacity utilization (about 45%), shortage of grain and food processing by-products, and a 16% VAT charged on some feed ingredients used in ration formulation (interview 26). AKEFEMA is lobbying for extending VAT exception to the feed ingredients left out in the 2016 budget (interviews 12 & 26).

Impact of feed and fodder costs on the cost of producing milk
Farmers generally point to high cost of feeds as a constraint for their enterprise performance (PPD Consultants, 2013). Recent analysis shows that overall costs for feeding stands at 67% of total costs of production (Perfometer Solutions, 2013), which influences the cost of milk production and subsequently the gross margin. A challenge in dairy feeding is buffering seasonal scarcity of feeds which expose farmers to trade malpractices in feed markets with inconsistent quality and high costs. A study by (Wambugu et al., 2011) found that concentrates account for 34% and 26% of variable costs of production in zero-grazing and non-zero-grazing systems respectively. The next highest variable costs were for maintenance of real estate in zero-grazing systems (25%) and for labour (24%) in non-zero-grazing systems. Fodder accounted for, respectively, 12% and 14% of variable costs. The share of costs of fodder and concentrates, including farm-grown feed and fodder, has increased over the years. According to Muriuki (2011), in 2008 feed prices increased from KES 100 to KES 200 per bale of hay and from KES 1,000 to KES 1,400 per 70 kg bag of concentrates. Today's concentrate prices are as high as KES 1,650 per 50 or 70 kg bag, depending on the quality (interview 6). The resulting rise in farm gate prices is threatening the competitiveness of dairy production in Kenya vis-à-vis imports (see **Section 2.3.3.4** for more detail).

2.3.2.2 Reproduction and breeding

Kenya is relatively advantaged compared to neighbouring countries with respect to high potential for milk production of the dairy herd. A study for the East Africa Dairy Development (EADD) program found that 55.6% of households in Kenya keep Holstein-Friesian(s) (crosses), compared to 30.1% in Rwanda and 16.4% in Uganda (Mburu et al., 2011); in addition, Ayrshire(s) (crosses) were kept by 49.6% of Kenyan households. The main challenge is to tap the full genetic potential of the current herd through improvement of dairy cow management.

AI is an established practice in Kenya, although AI service use has declined, attributed to neglect of the dairy sector after the liberalization and collapse of KCC in the 1990s (Baltenweck et al., 2004); Makoni (Makoni et al., 2014). A number of genetics and breeding service providers are active, including ABS TCM, World Wide Sires, and Indicus. Kenya Animal Genetics Resource Centre (KAGRC) has been the main (public) supplier of semen for AI for a long time and increased production from 40,000 straws in 1996 to 1 million straws annually to date. Nonetheless, KAGRC's market share has fallen from 90% to 60% between the 1980s and 2010s (interview 8). Total import of semen by private service providers has increased to 400,000 straws in 2015 (Makoni et al., 2014). Apart from this reliance on imported semen, other issues that affect maintenance and improvement of the genetic quality of the dairy herd through reproduction and breeding service include:

- *Expensive AI services* – in 2013, PPD Consultants (2013) found that AI services cost between KES 600 and KES 3,000 per insemination, with semi-zero and zero-grazing farms incurring the higher costs. Some of the County governments subsidized AI and sexed semen at a cost of KES 700 for AI and KES 2,500 for sexed semen, which is half the current market rate (interview 11).

- *High AI failure rate* –The high AI failure rate increases production losses as well as costs. It could be due to low semen quality (PPD Consultants, 2013), poor inseminator skills, or poor body condition of cows at the time of insemination; the combination of all exponentially decreases success rates. Farmers complain that they sometimes get calves of different breeds from what they asked for (PPD Consultants, 2013).

Zero-grazing units are widely adopted in more intensive systems

These factors lead farmers to resume the use of bulls, considered less expensive and more reliable but often at lower genetic potential, often even downgrading the offspring (PPD Consultants, 2013)., which seems to be the case especially in the marginal and low production areas of Western Kenya and Nyanza (Muriuki, 2011); (Lawrence et al., 2015) found that 87% of farmers involved in the EADD program use bull services, while 54% preferred AI services; the challenges described above provide a possible explanation for the discrepancy between actual and preferred use of AI services by smallholders. Farmer preference for AI service is a pointer that declining AI use can be reversed by improving service characteristics to suit farmer preferences. Ommondi et al.'s (2016) study of farmers' preferences for AI services in dairy hubs shows that farmers prefer the service to be embedded in hub input services with flexibility in payment agreements.

Another cost constraint in herd reproduction is the high cost of stock of upgraded and pure breeds. On average, costs for a good heifer range from KES 80,000 to KES 200,000, which is prohibitive for most smallholders (PPD Consultants, 2013). The median price of a cow of improved breed is 24% of the median annual net income of rural households, thus amounting to a major cost for farmers (Burke et al., 2015). The high cost of quality heifers reflects shortage of replacement stock, which a study in Western Kenya estimated is 43% of the total demand for heifers annually for smallholder farms (Bebe et al., 2014). Some medium- and large-scale farmers seize this opportunity and sell heifers to other farmers.

In addition, calving intervals are generally large, up to 450–500 days (PPD Consultants, 2013; interview 12). This is attributed to inadequate feeding, poor heat detection, high insemination failures, poor herd health and lack of herd recording for decision-making (ACET, 2015; PPD Consultants, 2013). The high calving intervals are estimated to cause a production deficit of 450–500 million litres of milk per year nationwide, worth over KES 4 billion (MoALF, 2010a), which was roughly the annual intake of the formal chain during that period (see **Figure 1.2**).

2.3.2.3 Animal health services

Several animal diseases threaten farm productivity. By far the biggest challenge is East Coast Fever (ECF), which has a prevalence of 45–50%, and is reported by 85% of farmers as being the primary cause of cattle mortality (FVM, 2010; MoALF, 2010a). Other major threats are diseases such as brucellosis, lameness, mastitis, tick-borne diseases such as heart water and yellow fever, and transboundary animal diseases such as foot-and-mouth disease and lumpy skin disease; other threats include anthrax, helminthiasis, contagious bovine pleuro-pneumonia and Rift Valley fever (ACET, 2015; FVM, 2010; Makoni et al., 2014; MoALF, 2010a). Climate change is likely to come with more adverse weather conditions, creating extra animal health hazards and an expected increase in outbreaks of transboundary animal diseases, tick-borne diseases, helminths and other diseases (MoALF, 2010a).

Direct economic losses from disease outbreaks come from cattle mortality and reduced milk productivity (Makoni et al., 2014). Zoonoses also pose a direct threat to public health – for instance, brucellosis – and an indirect threat if milk quality is reduced – for instance, through increased drug residue content.

Veterinary products, both preventive and curative, are widely available in agrovet shops and through DFCSs. The animal health assistants and veterinarians provide easy access to veterinary services (Kruse, 2012); MoALF, 2010a), but they are relatively expensive. MoALF estimates that acaricide treatment costs range from KES 200 to KES 2,000 per animal per year (MoALF, 2010a). Single acaricide spraying of a dairy cow may cost KES 30 (SoG, 2015). It is estimated that in most areas, less than 50% of the communal dips are operational due to poor maintenance and management (FVM, 2010). Communications with stakeholders would suggest cost is an issue here as well, as repair of communal dips may cost up to KES 300,000, unaffordable for many groups of farmers (SoG, 2015); maintaining the proper acaricide concentration in the dipping stations is a continuous challenge (FVM, 2010).

The cost of ECF curative treatment has been reported at KES 1,000–4,000 per animal per treatment (USD 10–40) (MoALF, 2010a). On average, smallholder farmers in Nakuru, Nyamira, Bomet, Kisii Central, Uasin Gishu, Lugari, Nandi North, Trans Nzoia and Bungoma counties spend on average KES 898 per cow per month on health care, varying from KES 50 for vaccines to KES 4,000 for ECF drugs, compared to a monthly family income from milk of KES 750–45,600 (FVM, 2010). This means that the share of income spent on disease treatment can be considerable.

2.3.2.4 Farm and dairy equipment and maintenance services

A challenge to farmers is the cost of farm and dairy equipment, be it bailers, feed mixers, dryers, tractors or milk-cooling equipment (interviews 10&15; (De Jong, 2015); MoALF, 2010a). The majority of smallholders are unable to invest in equipment. Medium- and large-scale farmers invest in equipment such as fodder production machinery, but face utilization capacity problems (Ettema, 2015), owned equipment standing idle most of the time.

Maize silaging at large scale farm in North Rift

An opportunity here is for agricultural contracting service provision, which KMDP has piloted with Nundoroto Ltd: In Eldoret, 2015, the (medium- and large-scale) EDFA members managed for the first time to bring down costs of fodder harvesting by letting Nundoroto contracting company pilot a 'maize train', which brought together two harvesters, tractors with tippers, and a bulldozer from various farmers to speed up harvesting and silaging. The Service Providers Enterprise Network (SPEN) is offering a similar silage contracting service to smallholder farmers, in this case conducted mostly manually (Ettema, 2015).

DFCSs, milk processors and a growing number of small private entrepreneurs are engaged in establishing collection and bulking enterprises (CBEs) for raw milk (MoALF, 2010a). However, purchase and maintenance of milk-chilling, -testing and -holding equipment is expensive (ACET, 2015; Kruse, 2012; MoALF, 2010a). NMCS, for example, spends KES 150,000 annually on repair and maintenance of their three cooling hubs (interview 9).

DFCSs and larger farmers also move into processing and marketing ("forward integration") (ACET, 2015); however, major constraints preventing DFCSs investing in processing equipment are the cost and ensuring capacity utilization (interview 9). While the use of refurbished equipment provides an opportunity – the challenge is to ensure the quality of the refurbished equipment.

2.3.2.5 Training and extension services3

Twenty years into post-liberalization with its devastating impact on farmer advisory services and farmer knowledge and skill levels, recent operational data and reports derived from dairy development programs indicate a gradual improvement in DFCSs' and private sector's response to demand and supply of dairy support services (including training and extension services [T&E] and private dairy

[3] *This section is largely drawing on Katothya and van der Lee, 2016*

advisory services). The push factors include a growing number of dairy entrepreneurs taking dairy farming as a commercial venture and a sustained agribusiness focus by dairy development programs. The pull factors include accelerated demand for milk and dairy products and increased investments in milk marketing and processing infrastructure.

Recent experiences indicate that innovative institutional arrangements have been evolving in response to accelerated demand for dairy advisory services. Such models for facilitating farmers' access to extension and input services include the milk shed approach, the dairy chilling hubs and the milk collection and bulking enterprises (CBE) models. They have tended to be anchored on partnerships between DFCSs and other value chain actors and support service providers ("bundling of services"), and have been facilitated by donor funded projects such as EADD (led by Heifer International) and KMDP (SNV Kenya). Their common features include in-house business units and outsourced arrangements for facilitating farmers' access to inputs and extension services.

As a result, the Kenyan dairy sector has recently been profiled as a smallholder-based, private-sector integrated, and commercially-oriented sector with wide pro-poor benefits (Ngigi, 2005). Others have argued that the value chain meets preconditions for private sector driven governance structures (Makoni, et al., 2014), which are emerging in bundled service models by processors like New KCC. Since it is commercially oriented and dependent on a range of interlocking advisory services and input provision, others have contended the sector meets a key precondition for demand driven advisory services (Morton and Miheso, 2000). However, other pro-poor voices have urged for a differentiated sector development strategy, viz. a dual strategy under which pro-poor oriented programs target subsistence oriented farmers, while private sector oriented programs target dairy entrepreneurs willing to invest in dairy production on a commercial mode (Staal et al., 2008a; Staal et al., 2008b) KNDMP, 2010; Makoni et al., 2014). These varying objectives or pathways on dairy development ultimately influence the design of T&E approaches promoted. Please see Section 2.5.3 for more detail on the innovation support system.

2.3.3 Issues with milk marketing

2.3.3.1 Secure milk supply and bundling of inputs and services

With four dairy processors dominating the market (ACET, 2015), farmers and their cooperatives need to ascertain their ability to supply milk throughout the year to maintain bargaining power with the processors. The two biggest challenges for the cooperatives include the seasonality of milk production and the competition in milk procurement with informal sales (side-selling), which members engage in to diversify milk income streams to the household.

Side-selling is possible because of a ready alternative market available to farmers: milk traders, local markets and neighbours offer direct cash and prices that are up to 70% higher under informal or contractual agreement with the traders (ACET, 2015; Kruse, 2012; interview 11). The establishment of processor-owned bulking points closer to the farm also provides an incentive for farmers to sell their milk there rather than to the cooperative (Kruse, 2012). The relationship between traders, processors and cooperatives is complex, as some traders do source milk from cooperatives and sell milk to the same processors who buy from those cooperatives (ACET, 2015). These traders compete with processors for milk procurement; some offer one-month advance payment to farmers to secure milk supply, thereby outcompeting cooperatives and processors who enter into longer wait payment arrangements with farmers for milk delivered.

Competition for milk is fierce but seasonal

Seasonality is linked to fodder and feed access, as described in **Section 2.3.2**. Lack of consistent milk supply in the formal DVC leads to seasonal underutilization of bulking and cooling capacity in the dry season at both CBE and processor level, which subsequently compromises business profitability and risking inflation of consumer prices (Makoni et al., 2014). In contrast, during the glut season, milk bulking and chilling capacity is insufficient.

To address productivity, seasonality and supply chain loyalty issues, value chain actors are developing a range of models that bundle inputs and services, including:

- The **dairy hub model** promoted in e.g. the EADD program (see **Box 1**) has stimulated farmers' investment in chilling tanks for bulking and integrated access to inputs and services as a way of building farmer loyalty and mobilizing large volumes of milk (Kilelu et al., 2013; Kruse, 2012). Yet, results have been mixed as an EADD-I project evaluation showed that there were "tremendous difficulties" related to keeping farmers "loyal, active and engaged" (Firetail, 2013; Kilelu et al., 2013).
- **Pre-financed input and service provision by the processor** as practiced by NKCC is a form of value chain financing and input and services provision that offers many advantages to farmers. Inputs and services provided by contracted suppliers are first paid by the processor, who deducts them from the milk payments later. Services can include milk transportation, AI, veterinary services, and feed, but also insurances and extension services that focus on reducing seasonality and improving productivity and milk quality (interviews with nKCC and MCDFCU).
- In combination with the previous, offering a year-round **guaranteed offtake and a stable milk price** at competitive levels is another strategy to improve farmer loyalty. The alternative for farmers is to accept significant reductions in farm gate prices and processor-imposed ceilings on collected volumes at the onset of the glut season. New KCC as well as Meru Central Dairy Farmers Cooperative Union (MCDFCU) have employed this model and report realising improved farmer loyalty (interviews 1&2; (Katothya and van der Lee, 2016).

Box 1: Dairy business hubs and strengthening the supply chain – the EADD experience

While the growth of the dairy sector in Kenya presents many opportunities along the value chain, most smallholder dairy producers are unable to transition from subsistence to commercialized production. Key limiting factors include high transaction costs and other bottlenecks in accessing inputs and services (Kilelu et al., 2016). The dairy hub model is one innovative approach developed to address this challenge. The dairy hub entails a farmer-owned and -managed milk stock and chilling centres established in various rural areas. These centres become agribusiness centres that support and attract a network of businesses delivering inputs and services to the farmers who supply milk to the farmer-owned enterprise (Kruse, 2012). The East African Dairy Development (EADD) project in Kenya aimed to support the development and scaling up of dairy hubs in the Rift Valley and Central Kenya regions (Mutinda et al., 2015).

The dairy hub aims to build a robust dairy supply chain through a variety of business strategies and social relationships that are formed with the interests of all value chain actors in mind. Hubs can create opportunities for and transform private sector participation in the dairy sector. They have been proven to be potentially strong platforms for improving access to markets, inputs and services for men and women smallholder dairy farmers alike. Indeed, they are transforming rural regions (Kilelu et al., 2016; Mutinda et al., 2015).

CBEs add services and supplies such as agrovet shops, animal health assistance, veterinary services, AI services and extension services. Farmers delivering to the chilling hubs have a credit facility based on their milk delivery. When they need input supplies or services, these are "checked off" from their balance. Hence the chilling hub functions as a financial intermediary trusted by all parties.

2.3.3.2 Access to market (bargaining power)

Dairy cooperatives lack bargaining power against processors in an oligopolistic market where milk sellers are essentially price-takers (PPD Consultants, 2013). An example of the bargaining power of a large processor was described in interview 9 with NMCS. NMCS had negotiated a milk price of KES 37 per litre for a year with the processor. Yet when milk volumes started to increase and reached levels above 60,000 litres daily, the processor decided to cut the milk price for the volume above 60,000 litres, paying only KES 32–35 per litre. When the daily milk volumes declined below 50,000 litres, the processor also cut the milk price. NMCS cannot sell the extra volume to other processors, because other processors suffer the same glut and volumes are too small to negotiate a good milk price.

In theory, an opportunity for dairy cooperatives would be to move into processing (forward integration). In practice, many DFCSs lack the scale and the management capacity to succeed in processing. DFCSs can successfully invest in processing at union (secondary cooperative) level if they can access affordable credit and mount aggressive market campaigns, as demonstrated by successes of Githunguri Dairy Farmers Cooperative Society and MCDFCU (interview 20; Rademaker et al., 2016a). From the interview with NMCS, it appeared that the two barriers withholding them from moving into processing are affordable credit to invest in a processing plant and the dominance of a few processors in the retail market, making it very difficult to penetrate that market with a new product (interview 9). Clearly, those barriers apply as well to the DFCSs.

2.3.3.3 Milk prices and profitability

Most farmers consider the current milk prices to be low compared to the cost of production (PPD Consultants, 2013). Milk prices vary greatly by region and type of milk buyer, and generally highest milk prices are paid by milk traders, close to urban areas. According to a farmer close to Nakuru town, a milk trader pays KES 45–50 per litre (interview 11) on spot at the farm gate; in Eldoret, delivery to institutional customers will yield KES 60 per litre (interview 10), while farmers receive KES 32–37 for bulk milk, which' payment is not on spot, while farmers prefer on spot payment regimes to meet their urgent cash needs.

As previously noted, the cost of milk production in Kenya is relatively high, which is attributed to inadequate farm management, high external input costs and low economies of scale of the primary producers (Muriuki, 2011). Farmers using a zero-grazing system with high input costs are particularly challenged to make a profit (ACET, 2015). However, the production system alone does not explain all the variance, as ACET (2015) reports that farmers using a zero-grazing system around Githunguri had the most profitable businesses – in terms of gross margins – of a sample group that included both zero-grazing and non-zero-grazing systems in multiple regions.

Although the processors have significant bargaining power, their estimated profit margins are not very high (10–20%), which is in line with international standards (Technoserve Kenya, 2008). ACET (2015) has suggested that those relatively low profit margins, given processors' strong position, can be explained by the presence of a much larger and highly competitive informal sector. To compete with the lower prices in the raw milk chain, supermarkets such as Tuskys have started to sell raw milk in milk dispensers (ACET, 2015), showing that retail sales models will change to reflect consumer preferences for raw milk.

2.3.3.4 Sector competitiveness in the regional milk market

Due to increased demand in Kenya and relatively low production costs in Uganda, Kenya is currently a net importer of milk (interview 12; De Jong et al., 2015). Production of value added products such as milk powder, ghee, yoghurts and cheese is growing, but still low overall. 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 that facilitate regional trade, including the Common Market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) (PPD Consultants, 2013). In the broader African region, demand for milk is expected to increase across the board following increasing populations, urbanization and rising incomes (Makoni et al., 2014). The main challenge for Kenya in operating successfully in the regional markets is to improve milk quality and lower the cost of milk production (interview 3; MoALF, 2010a). Record keeping from the farm level up will be of utmost importance to enable traceability, which is a prerequisite for penetration of regional markets.

2.4 Bio-physical drivers and trends – environmental impact

The growing demand for milk is being met by more smallholders taking up dairy farming to improve their welfare and livelihood. This widens the geographical spread of milk production, with more smallholder farms in the country across diverse agroecosystems (Muriuki, 2011; (Bebe et al., 2002). Most smallholders meet the growth in milk demand and supply by increasing their herd size; this presents ecological threats, as the required feed resources have to be produced by changing land use (i.e. increasing the area of land used for dairy farming rather than sustainably intensifying) with consequences of degrading land, soil, water and agrobiodiversity, e.g. when dairy breeds replace the indigenous cattle population. The dairy sector hence faces several environmental challenges with respect to soil erosion and nutrient mining, water pollution, waste and manure management and greenhouse gas emissions. However, there is limited awareness of the environmental impact of the sector (Muriuki, 2011; Makoni et al., 2014). The prevailing mixed farming systems offer opportunities to address some of these challenges, for example, through use of manure for crop fertilization and integration of legume fodders, which fix atmospheric nitrogen for soil fertility and crude protein in fodder for livestock (Herrero et al., 2010). 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 (CCAFS, 2015).

In a recent study on environmental impacts of dairy farming in Ethiopia, de Vries et al. (De Vries et al., 2016) showed that three categories of interventions contribute to reduction of environmental impacts of Ethiopian DVCs: i) Improving productivity of dairy herds in terms of milk and meat, both at animal and herd level; interventions include improvements in feeding, breeding, herd composition, health and housing; ii) Professionalization of the post farm-gate DVC to reduce milk losses; and iii) Improving nutrient use efficiency for sustaining dairy production in the long term. They found reductions of 2-29% in GHG per kg of milk, 2-39% in land use per kg of milk, and 0-72% in energy use per kg of milk respectively as results of interventions in the DVC.

2.4.1 Soil erosion and water pollution

Negative environmental impacts of the dairy sector in Kenya include loss of vegetation through overgrazing of natural pastures (Muriuki, 2011). As extensive grazing is mostly practised 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 (Bebe et al., 2002). Another issue is surface water pollution, mainly from milk bulking and processing activities, and water depletion in the peri-urban areas when farmers use borehole water (Muriuki, 2011).

2.4.2 Nutrient cycling and manure handling

In more market-oriented farms, external input use is higher, affecting nutrient balances. The handling of manure in urban and peri-urban areas may lead to eutrophication and pollution of groundwater. Muriuki (2011) notes that such concerns over environmental pollution within urban and peri-urban areas may lead governments to limit dairying in those areas, which poses a threat to the dairy sector. An opportunity is to improve manure management on farms which can save expensive fertilizers, improve soil quality, and improve the quality of life of both humans and animals (Makoni et al., 2014; Nyaanga et al. forthcoming) through the application of increased amounts of organic matter from manure. Napier grass requires fertilization and is regarded as a nutrient mining crop. Its use can result in soil depletion if not sufficiently fertilised, which is a common practice in the Kenya highlands. Furthermore, dairy manure can be transformed into biogas. The International Fund for Agricultural Development (IFAD), GIZ (the Deutsche Gesellschaft für Internationale Zusammenarbeit), the Kenya National Farmers Federation (KENAFF), SNV and Hivos all support the construction of biogas mini-plants on dairy farms (Kimanthi, 2015), interview 14). The uptake of biogas by farmers is, however, constrained by low levels of education and awareness of the technology, financial access, non-fit with production system used and limited land tenure security (Mwirigi et al., 2009).

Production of high-energy and high-protein fodder crops is an important foundation for productivity in intensive systems

2.4.3 Greenhouse gas emissions

Dairy farming contributes to greenhouse gas emissions, with relatively higher emissions for lower yielding cows and cows fed on lower quality feed and fodder (interview 25). Increasing the efficiency of milk production through increasing milk yields and/or changes in dairy cow rations provides opportunities to reduce relative greenhouse gas emissions and also has economic efficiency advantages (Makoni et al., 2014). However, studies of greenhouse gas emissions in Central Rift Valley smallholder farms observe that better feeding is only possible for farmers endowed with resources (Udo et al., 2016; Weiler et al., 2014). This would mean exclusion of the majority of resource poor farmers from making contributions to mitigating greenhouse gas emissions.

Ongoing work among smallholders in Kiambu, Uasin Gishu, Meru and Kisii Counties (Nyaanga et al. forthcoming) and Nandi County (interview 25) reveal that from an agronomic perspective, much room exists for improvement of manure management and for investments to increase farmers' income and welfare and reduce costs of production.

2.4.4 Agrobiodiversity – loss of indigenous cattle breeds

Many development efforts emphasize breeding for improved dairy cow performance, usually meaning higher milk yields. These efforts promote superior genetic material that are mainly exotic dairy breeds. Hence, farm animal biodiversity being less in more market oriented milk production. These development strategies expose indigenous cattle breeds such as Zebu to increased risk of extinction (Mwai et al., 2015; Ruto et al., 2008). 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.

2.5 Social-political drivers and trends

Social-political drivers and trends concern social-political developments around the value chain, institutional governance developments, and developments in the innovation support systems.

2.5.1 Social-political issues around the value chain

Cultural differences
The geographical spread of dairy uptake in Kenya by smallholder farming households has broken inherent cultural differences while widening differences in commercialisation perspectives in dairy that are of relevance to sustainable dairy intensification. A common feature is that dairy has multiple functions, but the weight to each function varies depending on cultural preferences, next to farm proximity to consumption centres, dairy processing plants and presence of a cooperative society that promotes input and output services supportive to dairy development. In general, farming communities closer to urban consumption centres, processing plants or cooperatives have taken to more market-oriented dairy and utilise dairy genotypes while those further away are less market oriented and utilise indigenous or dual purpose genotypes. Farming communities in areas with a long tradition of grazing and dairy consumption, like the Kalenjin in the Northern Rift and neighbouring areas, may stick to grazing longer than communities that adopted dairy production more recently (Udo et al., 2016; Weiler et al., 2014).

Processor oligopoly and level playing field
More market-orientated dairy households are vulnerable to market dynamics in feed and milk prices, often with negative impacts on their farm economic viability. As described before, the Kenyan DVC is characterized by a "processor oligopoly", where four processors hold the majority of the processed market share (ACET, 2015). This concentration of power can be seen as problematic, as abuse of this power position is a continual temptation for processors and a threat to the livelihood of farmers. This trend towards power consolidation is not peculiar to the Kenyan dairy sector, but a trend in agricultural value chains worldwide (Econexus, 2013). The trend can lead to exclusion from growth for the majority of smallholders producing milk for livelihood benefits. As well, it may disadvantage

consumers in product price and quality standards. It is therefore important to have public discussion about whether and how to regulate market power and/or enforce regulations.

Public health risks

The unprocessed milk chain is typically accused of facing severe milk quality issues, among which are high levels of hazardous bacteria, aflatoxins, preservatives and drug residues, as well as adulteration of milk. Yet, bacterial loads above KeBS standards (<30,000 cfu/ml for total bacteria counts) have been reported for both raw and processed milk (Omore et al., 2005). (Langat et al., 2016) found that aflatoxin-content of processed milk was lower than in raw milk, which was attributed to the heat treatment that milk undergoes in the factory (more on this below). Utilization of different dairy genotypes is managed with indiscriminate use of antibiotics, especially for mastitis, ECF and endo-parasites, but without adherence to prescribed withdrawal periods, thereby exposing consumers to health risks. Antibiotic drug residues are found in equal amounts in raw and processed milk samples (9% at consumer level for raw milk samples and 8% for processed milk samples), as heat treatment does not affect drug residue levels (Omore et al., 2005). Processors have also been blamed for preserving milk with illegal preservatives such as hydrogen peroxide. Clearly, more research is needed here to identify critical control points (e.g. (Ndungu et al., 2016; Orregård, 2013).

Dairy farming and milk consumption pose several disease threats for humans, which in the Kenyan context mainly concerns brucellosis, tuberculosis, cryptosporidiosis and aflatoxicosis (Arimi et al., 2005; FVM, 2010; Kang'ethe et al., 2007; Kang’ethe et al., 2012; Kang’ethe et al., 2010; Namanda et al., 2009; Yard et al., 2013). Milk is mainly used in tea and the milk is heated before being consumed. This heating of the milk effectively reduces the risk of obtaining brucellosis and tuberculosis via the milk (Arimi et al., 2005; Kang’ethe et al., 2010; Namanda et al., 2009), but the effect of boiling on the risk of getting aflatoxicosis is not clear (see discussion in Langat et al. [2016]). (Yard et al., 2013) mention several interventions to reduce aflatoxin exposure that have proved effective in controlled studies.

Business models to improve milk quality include a quality-based milk payment system (QBMPS) with which Happy Cow is experimenting, supported by KMDP (interview 3). In this system, dairy farmers are paid according to the quality of milk they supply. A challenge with QBMPS is, however, that the processor needs to pay a premium price for the milk to provide an incentive for farmers to deliver the milk to them, as alternative markets are available.

Dairy value chain and inclusion of youth, gender and resource-poor farmers

Dairy farming is dominated by the older generation. According to officers at MoALF, the average dairy farmer is 60 years old. **Young people** are underrepresented ‘because they want quick money’, while dairy farming is slow in returns and needs hard manual work (interview 12). However, a study by (Sulo et al., 2012) identified lack of access to capital and resources such as land, lack of skills and inadequate financial services as the main constraints preventing youth from participating in dairy farming. It is estimated that 64% of youth in Kenya is unemployed (Njenga et al., 2012) so creation of employment opportunities is a strong priority in rural areas.

There are opportunities for the youth to engage in other DVC nodes, including in feed businesses and milk bars/vending (Sulo et al., 2012). Many young men are getting into the milk transporting business because roads are in poor condition and milk loads may be heavy – up to 200 kg – so the physical strength they have is their advantage in handling the motorbike (Kruse, 2012); interview 20). Young people also enter farming when they inherit land from their parents; they can become entrepreneurs if they are willing to commercialize the farm (De Jong et al., 2015). Usually young people increase farm productivity by using the land they own as well as fallow land they lease from other farmers, on which they put extra dairy cows (De Jong et al., 2015).

In Kenya, most peri-urban dairy farmers are **women**. They keep about the same number of cattle as men, but men are more likely to own improved dairy cattle (Kristjanson et al., 2014). However, in most cases women’s roles are mainly in dairy cattle husbandry, while men do the marketing. This division of roles and responsibilities increases the risk of abuse by men, as they are in control of the money (Makoni et al., 2014). The Government of Kenya (GoK) is committed to achieving gender equity as enshrined in the 2010 Kenyan Constitution (RoK, 2010).

The issues of access to land, extension services, information and training, and credit affect women differently from men (Makoni et al., 2014; Kristjanson et al., 2014; MoALF, 2010a), hindering female-headed households from tapping into economic opportunities in the dairy sector. Women overcome the issues of access to credit by forming cooperative microfinance systems (Kristjanson et al., 2014). Although loans obtained from such women's groups typically go to non-income-earning activities, some groups allow loans for dairy production purposes (Kristjanson et al., 2014). Specific credit opportunities for women are available through the Kenya Women Microfinance Bank and the parastatal Women Enterprise Fund (WEF [WEF n.d.]).

Female participation in leadership positions is low in dairy cooperatives, unions and associations (Bebe et al., 2016). Yet it was noted during an interview that the most successful cooperative boards are balanced in terms of expertise, age and gender (interview 23).

In the interviews it appeared that most people are in favour of a move away from a supply-driven approach towards a market-led approach in the sector. This raises the question what further commercialization will mean for the livelihoods of the estimated 1.8 million or more **small-scale dairy farmers** (ACET, 2015). It is to be expected that with increasing investments in the dairy sector, production costs of resource-poor farmers will remain uncompetitive, resulting in one of three options: "hanging in", "stepping up" or "stepping out" (Dorward et al., 2009). However, given the high unemployment rate among youth, especially in rural areas, the question is what other livelihood options are, or will be, available for those who quit dairy farming and their children.

Animal welfare

Animal welfare generally is not considered an important and urgent (policy) issue in the Kenyan dairy sector. This is not to say that providing good care to animals is not considered important, especially in relation to improving productivity (interview 19). According to Makoni et al. (2014), important factors influencing poor husbandry practices of farmers are lack of resources, limited education and small land holdings. Currently, there are no development projects known with improving animal welfare conditions as an explicit focus. Yet, several aspects of animal welfare are crucial for improving dairy milk production as well, such as good housing, feeding and watering, and veterinary care. It seems likely that the issue of animal welfare will increase in urgency and importance when Kenya enters more into export markets, because of differing views on animal welfare across countries.

2.5.2 Institutional governance

A reliable institutional governance framework can guide the evolution of a common vision and coordinate sector players towards shared objectives. Institutional governance here refers to public–private cooperation, co-innovation and a public economic policy framework that supports private investment and enhances opportunities for (inter)national trade. This section summarizes the chapter on reliable institutional governance from (Rademaker et al., 2016a):

Harmonizing regulatory instruments – Since 2010, the development of appropriate policy frameworks has been the responsibility of the Government of Kenya, while the development of the sector has been devolved to the county governments; the latter implement service delivery, including veterinary, breeding and T&E services (interview 12; Makoni et al., 2014). Dairy-specific policies are numerous and scattered, which raises questions about their coherence and enforceability (see **Figure 2.3**). Generally, the enforcement of standards and regulations is limited, which does little to induce adoption and further innovation. Policies that directly target dairy research, training and extension are not yielding the innovations needed by the sector due to low engagement between relevant knowledge institutions and supply chain actors; consequently the ongoing research, training and extension is of limited end-user relevance.

Economic instruments and (dis)incentives for investment in dairy –The DVC is ranked high as priority sector in two-thirds of the counties according to the agricultural sector development programme of the government. Economic instruments that are used to promote the sector include:

Subsidies – Counties are implementing growth models including the 'one cow initiative' and subsidy programmes for delivering AI and installing milk cooling tanks to promote inclusive dairy development, targeting resource-poor households, youth, women and the disabled. These initiatives reflect a wider orientation of policies in promoting 'hardware', but this is not matched with the development of ‘software’ solutions, targeted training and advisory services, and data collection and analysis. A market distortion effect is the likely result of these approaches.

Cess, levies and taxes – Attempts to improve access to financial services for farmers until recently were hampered by steep loan conditions. The KDB raises significant funds, with which it is expected to regulate and promote the DVC. The environment for investors is rather unpredictable as the county governments are proposing to impose new taxes on many items. Unrealized tax opportunities for the sector include removal of VAT on dairy equipment and feed ingredients.

Soft instruments for promotion of collaboration and innovation, such as innovation platforms, public-private partnerships, and codes of conducts, are used sporadically, e.g. a pilot school milk program in Mombasa and Migori counties. Some starting points for increased collaboration exist, but increased stakeholder involvement, co-investment, and a more convincing role of KDB are needed for success.

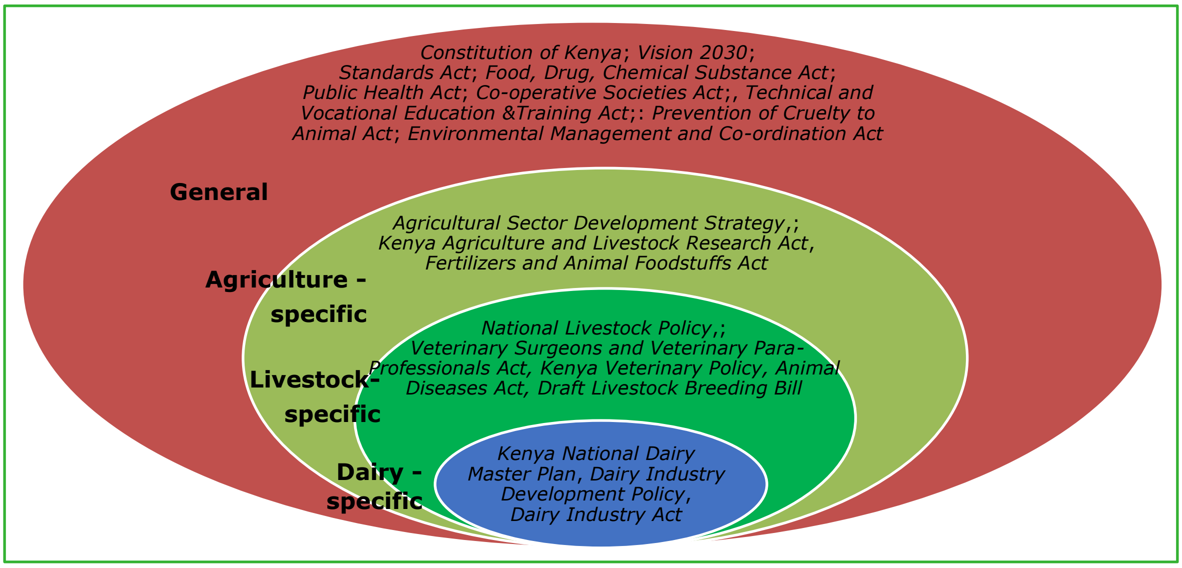

Figure 2-3 *The Kenyan dairy sector is regulated by a range of policies and laws, depicted here in concentric circles; wider circles represent policies and laws that less specifically target the dairy sector*

2.5.3 Innovation support system

The ability to address the challenges and exploit the growing opportunities in the dairy sector hinges on actors continually exchanging and applying knowledge, mobilizing resources and coordinating co-innovation networks. This section describes the key knowledge and innovation support system issues, including those with research, T&E and business development services engaged in the dairy sector. It is interesting to understand how the innovation support system interacts with the supply chain and policy and regulatory actors to support dynamic and continuous technical, institutional and social innovation in the sector. This section also examines the capabilities of innovation support actors and how different types of innovation support structures contribute to supporting innovation, focusing on actors, institutions, interactions and infrastructure (Wieczorek and Hekkert, 2012). The review draws heavily on the Chapter on Resilient innovation support system in (Rademaker et al., 2016a)

Stakeholder collaboration – Due to the lack of a shared vision for the dairy industry, the linkages between various actors are generally weak. Besides some pockets of coordinated action, there is no coherent innovation system for problem solving and to sustainably exploit opportunities to drive innovation in the sector (Odame et al., 2009). This is characterized by supply-driven research that is unresponsive to the sector needs, extension and advisory support systems that are equally ineffective, and education actors unable to meet the sector’s demand for skilled personnel (Makoni et al., 2014); (Muriuki, 2011); (Odame et al., 2009).

Furthermore, weak organizational capacity of various industry associations prevents effective interaction, investment facilitation and lobbying. Most donor-supported development interventions are not well-coordinated with other initiatives, resulting in duplication of efforts and limited cross-learning and co-creation. These gaps reflect underlying institutional challenges including lack of trust and dependability among value chain actors (Kilelu et al., 2013); (Kurwijila and Bennett, 2011). There is need to strengthen networks through platforms to foster dialogue and co-learning to drive innovation in the sector. Such platforms need to be championed and driven by the sector stakeholders. KDB is seen as key facilitator for such platforms, but needs significant strengthening to effectively convene and collaborate with stakeholders.

New models for innovation support – Some new approaches to supporting knowledge transfer and innovation support are occurring in the sector. The focus is on demand-driven, market-led approaches to dairy innovation support systems. Examples include practical dairy training centres, dairy business hubs, and private dairy business advisory services (Kilelu et al., 2016; Katothya and van der Lee, 2016). These innovation support services, coupled with emerging inclusive business models and public-private partnerships, are targeting to build capacity in relevant practical skills and entrepreneurial attitudes of smallholder dairy farmers, sometimes linked to medium- and large-scale producers or international experts., Investments by county governments also present opportunities for new partnership investments that can drive innovation. Nonetheless, there is need to understand how well these models are working.

Education and training of dairy professionals - Regarding the skills gap problem at T&E advisor level, this systemic issue has been widely acknowledged, especially by third sector and private sector players in most agrisectors in Kenya. Insiders seem to content that despite their slender and theory oriented educational preparations, Kenyan trained agricultural graduates are redeemable if put through a structured on-the-job training accompanied by coaching and mentorship (Katothya and van der Lee, 2016).

ICT and knowledge management – Development of ICT infrastructure has provided new opportunities for strengthening of innovation support systems, e.g. through development of dairy-specific applications that enable information and knowledge sharing. While many of these ICT initiatives are promising, uptake and effectiveness need critical assessment.

2.6 Concluding the analysis with a SWOT

The key strengths, weaknesses, opportunities and constraints for the Kenyan dairy sector are summarized in the SWOT table in **Appendix 1**.

The sector is experiencing a strong growth in demand for milk, which offers many opportunities that can translate into new investments and inclusive sector development. Opportunities for farmers in increasing milk production lie in increasing productivity with entrepreneurial dairy farm management skills linked to effective delivery of inputs and services and buffering of seasonality in feed, milk supply and processing intake capacity. Marketing opportunities for farmers lie in lowering milk production costs and improving milk quality in order to access the growing domestic milk processing capacity and the regional free trade markets.

However, for dairy farming to intensify sustainably, much more is needed than reacting to market opportunities. The scarcity of farmland requires ongoing intensification. For that intensification to occur in a sustainable way will require that the following challenges are being addressed: better *DVC integration* to enhance efficiency and sustainability of the sector through integrating best practices along the DVC; *improved linkages and trustworthy interactions* between farmers, input and service providers, and downstream supply chain actors to *reduce high transaction costs;* and effective efforts to *improve on milk quality and food safety* issues. Better DVC integration has to be dovetailed with *dependable regulatory, policy and innovation support systems* that ensure dynamic innovation of the sector through responsive research, farm advice and education, facilitation of stakeholder innovation platforms and fostering of individual innovations.

Widening the discussion beyond economic robustness towards social and environmental robustness attracts opportunities to evaluate other pressing issues, such as inclusive development of the sector and reduction of environmental impact. While attention for some social robustness indicators is strong–such as inclusiveness of smallholders and youth, and gender equity– attention for other social and environmental robustness indicators is minimal, such as viability of smallholder livelihoods, animal welfare, agrobiodiversity, water pollution, packaging waste, and manure handling and greenhouse gas emissions. However, scores for social robustness indicators are weak when it comes to product quality and safety, with public health risks high from zoonoses, antibiotics, aflatoxin, heavy metals and other hazardous substances in milking, feeding and health practices. This is strongly related to the low levels of farmer skills resulting from two decades of disinvestment in training and extension following the Structural Adjustment Programs in the early nineties (Makoni et al., 2014).

While the GoK policy ambition for the sector, embodied in the *Kenya National Dairy Master Plan* (MoALF, 2010ab), is to increase the share of the formal processed chain in the milk market and improve milk quality, little headway has been made. The market share of the formal sector remains under 30% following the strong domestic market for raw milk (chilled and unchilled chains) sustained by consumer preferences, consumer purchasing power and insufficient price and quality advantages of processed milk. The latter is a prime cause for inhibited growth of exports as well.

3 Sustainable intensification pathways

The section proposes answers to the question: While capturing the opportunities in the dairy sector, how can challenges and weaknesses be countered as to make intensification of the different dairy farming systems in Kenya sustainable?

3.1 Drivers and barriers

The strengths, weaknesses, opportunities and challenges for the dairy farming systems at use in Kenya were identified in Chapter 2. These SWOT elements can be considered to be the drivers and barriers for sustainable intensification (SI), for they describe the opportunities that farmers could capture (or already are doing so) and the challenges that they face (or that already have affected their farming systems). It is clear that the opportunities for the dairy sector already drive intensification – see **Table 2.1**. It is also clear that the threats and challenges that farmers face, dampen the intensification process and/or cause it to occur in unsustainable ways.

Land appears to be the most limiting production factor in the Kenyan highlands; the scarcity of land drives up prices and restricts sales. For dairy to have sufficient comparative advantage, the productivity per hectare (return on investment) has to be higher than for other crops and livestock – cash crops like potatoes, tea and coffee in rural areas, and horticulture and poultry in peri-urban areas. Intensification of agriculture thus means increasing the productivity of land, resulting in a change of land use over time (Dugué et al., 2011).

Intensification also shows the co-limiting character of other factors such as:

1. Access to dependable provision of inputs & services, such as feed, stock, AI and breeding services, veterinary services and drugs, farm and milking equipment, and extension/advisory services; proximity to urban centres being a key cause of this.
2. Access to dependable output markets, which includes attractive and stable prices, and dependable relationships between farmers and milk buyers.
3. Access to other production factors, i.e. skilled labour (with entrepreneurial, managerial, and technical skills), public infrastructure (roads, electricity, ICT) and capital, although reports differ on the limiting character of the latter and this could be included as financial services under item 1) (Bebe et al., 2002); ILRI, 2008; (Udo et al., 2011).

Limitations in these factors are being addressed to a certain extent by bundling of inputs and services by cooperative societies and processors, by privatization of input and service supply including training and advisory services, and by ongoing subsidization of cold chain equipment. Failure of adequate improvements in these three co-limiting factors will result in unsustainable intensification, evidenced by poor scores for profitability, working conditions, animal welfare, product quality & safety, nutrient balances, and GHG emissions. In extreme cases it will totally hamper intensification, with dairy remaining on low input-low output level, as farmers will consider that to be the best coping strategy or best resilience strategy.

Intensification practices observed - following 30-40 years of (gradual) intensification – include intensification in use of genetics, animal feeding and health care, and manure integration.

- Use of dairy genetics has developed to high proportions of Holstein Friesian cattle breed, dominating over Ayrshire then Guernsey and Jersey; there is increased importation of genetics and use of sexed semen among smallholders.
- Following paddocking and used increased of crop residues in semi-intensive dairy, intensive dairy animal nutrition has built increasingly on Napier grass for cut-and-carry systems till emergence of diseases (head smut and stunt) when other fodder crops started to gain prominence, both protein-rich and energy-rich forage crops, including Boma Rhodes, bana and Brachiaria grasses, yellow maize, sorghum, Lucerne, vetch, and lupine; in grazing systems, paddocking helps in

animal nutrition as well as disease management; in response to fodder scarcity, fodder trade and use of non-conventional feed resources gain importance.

- Farm-level disease management particularly has to deal with the challenge of ticks; in zero grazing systems, spraying is common, while in grazing areas communal dipping is practiced; ECF vaccination is picking up.
- Manure utilization in Napier grass fields is well promoted in extension messages, but finds stiff competition from vegetable gardens in smallholder farms with zero grazing units; as market for processed milk expands, farmer cooperatives are entering into milk processing ventures, many are supported to access refurbished equipment.

Also aiding intensification is market linkage infrastructure, including rural road networks, rural dairy hubs, and improved service delivery through diverse models to reach diverse farmers.

3.2 Ongoing development pathways

On supply chain level, the sector shows diverse pathways to market development that define the choices that farmers have when they become more market oriented. These can roughly be distinguished based on market channels as:

- **Conventional formal** – Processed dairy products for the middle class, with focus on volumes, market share and profit rather than on quality; use of external inputs governed by market dynamics and is increasingly bundled with milk supply contracts; supply is organized through milk collection centres (cooperative society- or private–owned) for smallholder farmers and direct collection from medium- and large-scale farmers.
- **Niche** – Quality products such as cheeses and healthy dairy products for upmarket consumer segments by processors like Biofood and Happy Cow, as well as other niche markets like organic dairy (Odhong et al., 2015); these require QA systems along the DVC to ensure milk intake free from antibiotics, aflatoxin and other substances; the price premium covers extra costs; supply is restricted to those farmers willing and able to meet the specific requirements of these markets.
- **Local bulk** – Raw milk marketing with emphasis on low costs, trust, distribution speed and/or affordability for consumers; it ranges from home delivery to milk bars to ATMs in supermarkets; quality largely is assured through personal relationships; supply is organized through private traders or directly from farm to retail outlet, by farms of all sizes.

What seems to be missing in the sector is debate on the relative advantages of and opportunities for these three pathways. As indicated in 2.6, despite strong policy focus on growth of the formal processed milk chain and despite significant public and private investments, market share of this chain does not grow significantly as a result of consumer preferences, consumer purchasing power and insufficient price and quality advantages of processed milk. Pursuing alternative pathways for the development of the informal raw milk market might break the deadlock that the sector is struggling with, characterized by chain fragmentation, health hazards and lack of competitiveness in the regional market due to high cost prices and insufficient quality assurance.

Such debate would also provide guidance in dealing with the trade-offs that selection of sustainable intensification pathways requires, notably between *people-planet-profit* objectives. Focus on either of these three would result in the following

Economic robustness – Reduction in cost of production and focus on entrepreneurial dairy farmers would result in scale enlargement of farms and exclusion of non-entrepreneurial smallholder farmers.

Social robustness – Focus on smallholder inclusion for food security, rural employment and livelihoods, with development of cooperative societies and addressing of inefficiencies in the chain, would have to deal with the tension between "development for all members" and "relevant services to the high producing members". Investments should focus on ways to market milk locally and/or with cottage type industries, rather than competition in the bulk milk sector with the larger processors

Climate-smartness – Focus on nutrient balance would favour local systems vs. traded feed and fodder, as well as manure management, energy efficiency and renewable energy.

Meanwhile, the same policies and investments mentioned above do make a difference in addressing the challenges the DVC is wrestling with, as **Box 2** illustrates.

Box 2. Turning around the fodder challenge: KMDP's work on productivity and business models

Access to quality fodder and feed is a systemic issue hampering the growth of a sustainable and competitive dairy sector in Kenya. SNV'S Kenya Market-led Dairy Program (KMDP) has an explicit focus on fodder supply chain development, aiming to increase efficiency and competitiveness of the DVC. KMDP carries out various interventions in the area of fodder development, conservation and mechanization practices:

1. Promotion of fodder practices through the dairy farmers cooperative societies (DFCSs) Training and Extension (T&E) unit, Service Provider Enterprise Network groups and development of fodder development strategies
2. Training of medium- and large-scale farmers with advice from international (Dutch) experts (in this case, PUM's senior expert program) and local agronomists (in this case, private dairy advisory service companies or local capacity builders, such as Perfometer Agribusiness Solutions Ltd)
3. Training of commercial fodder producers (CFPs) on improving fodder production and marketing through the same partners
4. Facilitating linkages between CFPs and local and international seed suppliers and between CFPs and dairy farmers.

Training is conducted through demonstrations, on-the-job coaching, and field days, focusing on agronomic as well as business practices. Demonstration pilots are established for a range of fodder varieties, especially protein-rich varieties.

Rademaker et al. (2016b) found that silage production among member farmers of DFCSs had increased significantly in most DFCSs, even if only few smallholders were growing and preserving new fodder crops (Rademaker et al., 2016b). De Jong et al. (2015) found that these KMDP interventions support improvement of fodder quality and availability during the dry season, thereby reducing seasonality of milk production at medium- and large-scale farms and in a number of DFCSs, notably in Meru Central Dairy Farmers Cooperative Union (MCDFCU)'s in Meru region.

Specific to interventions with individual CFPs, De Jong et al. (2015) report that 50 CFPs were established as businesses, and that fodder production and conservation had increased. Moreover, Rademaker et al. (2016b) found that sales of fodder seed suppliers had increased significantly. But CFPs and medium-scale farmers continue to face difficulties in accessing fodder seeds and equipment, including spare parts (De Jong et al., 2015). In Eldoret, the members of the Eldoret Dairy Farmers Association have come together to jointly harvest fodder using an innovative arrangement called the maize train, where different machinery owners combine their resources and schedule fodder production activities collectively (interview 10). Thus, there are business in contracting services for fodder production and harvesting and in repair, maintenance, financing and leasing of equipment. However, commercial fodder production needs to be complemented by feed rationing to satisfy the nutritional requirements of dairy cows and so increase productivity (interview 21).

While more systematic analysis of these approaches is needed, lessons learned so far indicate that fodder establishment and preservation have contributed to increased milk production among smallholders, thereby reducing seasonality of milk supply (interview 2).

Sources: Ettema, 2015; Perfometer Solutions, 2015; SNV Kenya, 2015.

3.3 Sustainable intensification pathways for dairy farming

In this section we return to the four cases described in **Section 2.1**. We describe the major SI challenges and choices that farmers in the different regions have to make.

Appendix 2 places the SWOT elements from **Appendix 1** in a perspective of strategy options towards SI, to deal with the major threats, risks, stresses and shocks that dairy farming is susceptible to. This framework was developed based on (Lebacq et al., 2013); (Duru and Therond, 2014); (Irwin and Campbell, 2015), with input from WLR colleague Theun Vellinga and authors. The table in **Appendix 2** shows how farmers at different intensification levels can – or should – have different SI strategies, depending on their current land use intensity, access to external inputs and services, and the markets they trade in. Intensification may (and sooner or later will) involve a shift to other markets, with the consequence that the production system has to adapt to the supply demands of that market (van der Lee et al., 2014a).

Below descriptions draw from the schematic overview in **Appendix 2.** We want to stress that these SI choices are not a menu to pick from, but mutually dependent interventions that need to be combined in a conscious strategy. Such an intensification strategy needs to deal with the following aspects:

a. ISP - Input & service provision - how will new inputs and services be accessed?
b. FM - Farm management – what farm practices need to be introduced? what skills need to be acquired?

c. VC - Supply chain connection – how and to whom will milk be marketed?
Choices may include the choice for integration in a particular chain, bundling of services, milk supply and ISP contracting, etc.

Coastal lowlands

- Sub-humid semi-rural: competing with crops and meat
- Low to medium land pressure, productivity limited by bio-physical conditions (climate, diseases)
- Low level of external inputs and services
- Low to medium access to milk markets - mainly direct consumers and traders
- Farm variation small to large, solely livestock and crop-dairy (LM-LM, LL-LM, SM-LM, SL-LM)

Key SI challenges
ISP- replacement stock, feed & fodder, animal health
FM - heat stress,
VC - collection assurance / price fluctuations

Potential SI coping strategies for low intensity farmers
ISP
- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs)
- Use of crossbreeds adapted to climatic and disease conditions
- Limit use of chemical inputs

FM
- Mixed farming systems with integrated farming practices (planting & growing season, species)
- Agrobiodiversity in seed/breed/species
- Drought-tolerant (fodder) crops
- Improved use of crop residues, including use of dual-purpose cereals for food and fodder and organic fertilizer
- Improved use of commons
- Conservation agriculture

VC
- Multiple clients
- Collective infrastructure creation & maintenance
- Collective input purchasing and output marketing mechanisms

Western

- Remote – and semi-rural: medium land pressure, competing with export crops and meat
- Medium level of external inputs and services (mostly private ISP)
- Medium access to milk markets - mainly traders and processors
- Farm variation small to large, solely livestock and crop-dairy (LM-M, LL-M, SM-M, SL-M)

Key SI challenges
ISP- replacement stock
FM - feed & fodder supply, reproduction
VC - supply certainty

Potential SI coping strategies for medium intensity farmers
ISP
- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs)
- Upgrading breeds to dairy grade cattle
- Use of advisory services, to assist in use of new technology and practices (management)
- Collective input purchasing and output marketing mechanisms

FM
- Intensify feed & fodder crops – choice of varieties, integration in farming practices
- Feed ration formulation and dry season feeding to reduce seasonality and optimize production
- Promote fodder legumes, cover crops
- Promote organic fertilizer use (compost, manure, crop residues)
- Promote green energy, e.g. biogas from dairy manure; solar, hydro, wind energy

- Judicious use of pesticides, drugs, chemical fertilizers
- Vary acreage cropped & number of animals kept
- Use of technology for fodder production and preservation and for milk handling
- Protection against epidemics - Vaccination

VC
- Become more market-oriented
- Collective infrastructure creation & maintenance
- Milk supply contracts

Rift Valley
- Semi-rural - Medium land pressure, competing with grains, cash crops and meat
- Medium level external inputs and services (mostly cooperatives and private ISP)
- Medium to good market access, through cooperative societies, processors and/or traders
- Farm variation small to large, solely livestock and crop-dairy (LM-M, LL-M, SM-M, SL-M)

Key SI challenges
ISP- farm advice
FM - seasonality of production
VC - supply certainty, prices

Potential SI coping strategies for medium intensity farmers
ISP
- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs)
- Changes in input levels (cost management) – feeding, breeding, health care, technology;
- Use of advisory services, to assist in use of new technology and practices (management)

FM
- Feed ration formulation and dry season feeding to reduce seasonality and optimize production
- Integrate fodder crops in farming practices
- Protection against floods, droughts, epidemics - vaccination
- Judicious use of pesticides, drugs, chemical fertilizers
- Vary acreage cropped & number of animals kept
- Choice of feed & fodder crops, cover crops, drought-tolerant crops
- Promote organic fertilizer use (compost, manure, crop residues)
- Promote green energy, e.g. biogas from dairy manure; solar, hydro, wind energy
- Water use management

VC
- Milk quality assurance
- Milk supply contracts
- Collective infrastructure creation & maintenance

Kiambu county
- Peri-urban: Land scarce; competing with horti-culture and poultry
- Good market access, through cooperative societies, processors and/or traders
- High level external inputs and services
- Farm variation small to large, solely livestock and crop-dairy (LM-H, LL-H, SM-H, SL-H)

Key SI challenges
ISP - quality assurance of inputs and services; replacement stock
FM - cost of production, management skills
VC - supply certainty

Potential SI coping strategies for high intensity farmers
ISP
- Contracting out fodder production and preservation
- Purchase of fodder
- Use of ICT options to enhance on-farm record keeping
- Use of advisory services, to assist in use of new technology and practices (management)

FM
- Purposeful breeding
- Feed ration formulation and dry season feeding to reduce seasonality and optimize production
- Commercial and/or on-farm fodder production and conservation
- Use of veterinary services, advisory services and record keeping to improve management
- Entry of young farmers willing to commercialize dairy (inheriting or leasing land)
- Use of new technology and practices
- Improve manure and nutrient management
- Judicious use of pesticides, drugs, chemical fertilizers
- Promote organic fertilizer use
- Promote green energy, e.g. biogas from dairy manure; solar, hydro, wind energy
- Leasing of land
- Irrigation

VC
- Promote fodder legumes
- Use of ICT options to enhance data collection for collection
- On-farm processing and other value addition activities

3.4 Sustainable intensification criteria and indicators

To assess and monitor SI pathways for dairy in Kenya, the critical points in the system where changes are required need to be identified, as well as indicators for these critical points. **Table 3.1** is structured using the seven attributes of sustainable systems as listed by (Astier et al., 2011) for the MESMIS framework, summarizes the critical points (challenges) for each attribute and lists potential indicators for monitoring of these attributes, selected from the indicators that have been described at various places in this report.

Table 3.1 *Critical sustainability points and potential sustainability indicators*

Attributes	Sustainability means:	Critical points	Potential indicators
Productivity	efficient and synergic use of natural and economic resources	Low productivity, high seasonality Low income High cost/low quality of inputs and services Epidemics and high disease levels	Production per cow/hectare/farm Calving interval Dairy income Cost of production (components) Farmer satisfaction w/ inputs and services Morbidity and mortality
Stability	presence and effectiveness of the negative feedback processes that allow maintenance of a state of dynamic balance at a constant productivity level, under normal, shock or stress conditions	Nutrient mining or eutrophication Indiscriminate use of chemicals Declining farm size / access to land Declining agrobiodiversity Water shortages Feed & fodder self-sufficiency	Nutrient balance (capacity to maintain-) Feed & fodder purchases Manure utilization Residues in milk and surface water Farm size – acreage and stocking density Breeds, fodder varieties, biodiversity GHG emission per kg milk/meat
Reliability		Unacceptable quality of milk Market demand shocks High price/low quality of purchased feeds	Food scares Milk quality standards enforcement Feed quality standards enforcement
Resilience		Failure to recover from shocks Changes in functions dairy cattle	Production curve Land use changes Adoption of innovations (skills to-) Capacity to anticipate on and deal with natural disasters
Adaptability	coping with changing socio-environmental conditions	Low capacity to adopt innovations Low skills - technical/management/ entrepreneurial	Utilization of advisory services, training, extension Farm performance recording
Equity	equitable distribution of costs and benefits amongst the different users of resources	Low bargaining power Low trust between VC actors Exclusion of smallholders, youth, women	Farm gate/consumer price ratio and seasonal fluctuations Age and gender distribution Livelihood indicators smallholders, youth, women
Self-reliance	enough independence and self-sufficiency to maintain farm performance despite the occurrence of external changes	Inadequacies in collective action VC fragmentation Processor oligopoly	Gross margin Farmer organization membership & functioning / effective collective action Diversity and quality of input- and service providers and milk buyers Dependable VC linkages Capacity to adapt to changes in market

4 Research needs

This case study identifies the following research needs on sustainable intensification (SI) pathways for dairy farming in Kenya. These research needs may inform other contexts as well.

We use the same five lenses used in Chapter 2, and address a number of key areas defined in the PIA literature review (PROIntensAfrica, 2016).

Further steps for this case study - The fact that this case study is in the 'light' category of the PROIntensAfrica program already denotes that more in-depth research may be useful. With the benefit of hindsight we realize that a sector-wide set-up of this case study has been rather ambitious and necessarily leaves quite a number of bases uncovered. In-depth research into specific dairy farming systems as well as comparative research into a limited number of them is expected to yield important additional insights.

4.1 Farming systems research needs

Sustainability indicators for different intensification levels and pathways

- This study confirms that farming systems can be classified by common notions of agroecological, climatic, farming objective, and farm size parameters, but also by parameters that indicate intensification levels: scarcity of most limiting production factor, access to markets, and external input level. A typology of farming systems that is suitable for research into SI pathways is important to tailor SI strategies to specific farming situations.
- Existing sustainability assessment frameworks (e.g. dairysustainabalityframework.org) were considered to be of limited use in this case study for two reasons: The indicators that they monitor are not necessarily covering the most critical issues for the Kenyan dairy sector, where social robustness currently is considered more critical than environmental robustness, and where land scarcity is the key limiting factor, as compared to labour scarcity in many Western countries and capital scarcity in some other developing countries. Appropriate indicators need to be identified for assessment of economic, environmental and social robustness of dairy farming systems at different intensification levels, for different intensification pathways, and for the DVC at large.
- Once identified, the indicators can be evaluated for associations of positive and negative externalities to inform pathways that optimize productivity while minimizing negative externalities. The research question would be: Which of the genetic, ecological and socioeconomic variables are significantly associated with herd productivity, depletion of natural resources or human and animal health risks incidences?

Land issues, including land availability

- Land scarcity in the main dairy areas in Kenya stimulates trade in fodder, feed and milk, importing those from other regions and from neighbouring countries. Trade-offs between social-economic parameters like availability and affordability of dairy products and environmental parameters like nutrient flow and nutrient balance need empirical assessment.

Yield gap, production systems design, and scarcity of inputs and services

- Quantify yield gaps and define interventions - Published milk yields suggest huge yield gaps within and between the production systems, genotypes, feeding practices and herd health management practices. However, this has not received adequate research attention to quantify the size of the yield gap and to identify promising interventions for the various intensification approaches that could address this gap.
- Assess the challenges farmers face in growing and preserving fodder, especially cost of production and opportunity costs.
- Evaluate fodder crops for different environments and intensification levels.
- Design and evaluate interventions to tackle seasonality of milk and fodder production.

- Evaluate management strategies to reduce long calving intervals and the farmers' complaint that AI services are unreliable, so as to provide tailor-made solutions.

Genotypes management

Considering the heavy reliance on replacement stock from outside the farming systems (be it from the Rift Valley or imported) and the strong preferences for imported semen of exotic dairy breeds and use of sexed semen, research is needed to:

- Evaluate costs of herd replacement for current practices and identify ways to reduce costs.
- Evaluate appropriateness of different breeds under different intensification levels in different agroecological conditions.
- Identify feasible business models for heifer production and young stock raising (off dairy farms).
- Evaluate practical, financial and ethical implications of technological innovations such as sexed semen (Asselt et al., 2010); (Olsson et al., 2006); (Sandøe et al., 1999).

Plant and animal protection

- Producing milk under zero grazing regime is popular with both rural and peri-urban dairy farmers, but status of implementation of on-farm biosecurity and animal welfare measures has not received research attention, even though there could be associations with production losses and herd profitability.
- Reflect on how animal welfare can be improved, and whether this can be achieved on an economic basis, with costs for better husbandry practices being offset by production improvements.
- Identify ways to improve availability, access and utilization of animal health care interventions for animal diseases, production diseases and zoonoses.
- Evaluate introduction of disease resistant fodder varieties for buffering of fodder seasonality.

4.2 Value chain research needs

Trade, consumption and value chains

- Evaluate models for improving loyalty and trust in the processed milk supply chain.
- Assess the potential demand for quality vis-à-vis the cost of quality and food consumption gaps.
- Evaluate how smallholders can beneficially comply with quality and safety standards for milk, which is currently a cause of food and economic losses to producers, processors, farmer cooperatives as well as consumers.
- Evaluate advantages and disadvantages of import tariffs.
- Evaluate self-regulation to understand (dis)enabling factors.
- Identify and evaluate ways to increase value chain competitiveness.

Innovation in partnerships

- Evaluate functioning and effectiveness of different input and service provision models like DFCS-managed and processor-managed integrated models (New KCC, MCDFCU, EADD, KMDP, SDCP) in supporting innovation and competitiveness of the sector.
- Evaluate ways to shape and strengthen public–private partnerships (PPPs) for AI, breeding and/or veterinary service delivery; focus on impact and additionality (to prevent unfair playing field for non-subsidized services deliverers).
- Assess influence of stakeholder groups on research agenda following privatization of research.
- Evaluate case studies of successful shifts from supply-driven to demand-driven research.
- Assess how sector-wide innovation platforms can be supported and institutionalized.
- Evaluate innovative financing mechanisms for VC actors, including value chain financing.

4.3 Economic sustainability research needs

Performance evaluation

- Identify and evaluate ways to significantly reduce cost of production, of processing and of marketing.
- Assess profitability of collection and bulking enterprises and its affecting factors.

- Evaluate efficacy of different commercial fodder production business models, at fodder farm level and at supply chain for dairy farm level.
- Assess governance mechanisms in the DFCSs and how they influence compliance with quality and safety standards, codes of conduct and implementation of good management practices (GMP); evaluate success factors that differentiate positive deviant DFCSs from others.
- Evaluate impact of innovation funds such as AECF on support of innovation in the sector.
- Design and evaluate quality assurance systems for feeds and fodders.

4.4 Social sustainability research needs

Public policies

- Review coherence of policies and organizational arrangements related to governance of the dairy sector, especially following devolution.
- Assess implications of compliance with milk quality standards and statutory revenue payments for farmers, DVC actors and the government, and how best to engage farmers in complying with the regulatory requirements for milk and stock market trading.

Food and nutrition security and poverty alleviation

- Explore inclusive development scenarios; consider whether private companies acknowledge the responsibility and are able to support inclusiveness.
- Evaluate inclusive market-led approaches being implemented.
- Develop and test appropriate indicators for socially robust DVC.
- Elucidate significance of parastatal funds and capped interest rates for DVC participation of youth, women and disabled people.
- Quantify cost of production and farm profitability for different farm sizes and farming styles.

Food safety

- Identify pathways to significantly improve quality of processed milk sector-wide.
- Evaluate health risks of consumption of boiled milk with high microbial counts or aflatoxins.
- Evaluate impact of milk quality assurance systems on product safety; same for feed quality.

Structures transformations, employment

- Evaluate effectiveness of novel training and extension interventions like practical dairy training centres, farmer study groups, private dairy advisory services, and training by input and service providers.
- Assess key dairy farm management skills that need to be acquired by farmers in different farming systems to realize genetic and agroecological potential.
- Evaluate interventions in provision of equipment, training and other services by counties.

4.5 Environmental sustainability research needs

Environmental impact

- Reflect on the benefits of preventing environmental degradation.
- Evaluate the dairy–environment nexus: what are correlations between dairy practices and environmental degradation, including greenhouse gas emissions, and the benefits?
- Develop and test appropriate indicators for environmental robustness of the DVC.

Nutrients cycle

- Evaluate nutrient balances for different farming systems and fodder interventions.

Identify and evaluate manure management innovations for land-scarce farms.

References

ABS/TCM, 2013. *Study on the Kenyan animal feed and fodder sub-sectors. Kenya Feed Industry Policy and Regulatory Issues*. SNV Kenya / Netherlands Development Organization, Nairobi.

ACET, 2015. *Promoting sustainable rural development and transformation in Africa - Kenya country report* African Center for Economic Transformation.

Aketch, A. 2014. ICIPE scientists develop disease-resistant Napier grass. *Business Daily*, 20 March 2014. Available at: http://www.businessdailyafrica.com/Corporate-News/Icipe-scientists-develop-disease-resistant-napier-grass/-/539550/2251996/-/iqsshwz/-/index.html.

Arimi, S., Koroti, E., Kang'ethe, E., Omore, A., McDermott, J., 2005. Risk of infection with Brucella abortus and Escherichia coli O157: H7 associated with marketing of unpasteurized milk in Kenya. *Acta tropica* 96, 1-8.

Asselt, M.B.A.v., Knapen, H.P.M., Lieshout, P.A.H.v., Prast, H.M., Prins, J.E.J., Vries, G.H.d., Winsemius, P., 2010. *Minder pretentie, meer ambitie: ontwikkelingshulp die verschil maakt*. Wetenschappelijke Raad voor het Regeringsbeleid / Amsterdam University Press, Den Haag/Amsterdam.

Astier, M., Speelman, E.N., López-Ridaura, S., Masera, O.R., Gonzalez-Esquivel, C.E., 2011. Sustainability indicators, alternative strategies and trade-offs in peasant agroecosystems: Analysing 15 case studies from Latin America. *Int. J. Agric. Sustainability* 9, 409-422.

Baltenweck, I., Ouma, R., Anunda, F., Mwai, A.O., Romney, D., 2004. *Artificial or natural insemination: the demand for breeding services by smallholders.* Nairobi, ILRI

Bebe, B.O., Mwangi, J.G., Ozor, N., 2016. Changes in agri-business outcomes among the dairy beneficiaries of contracted extension service delivery model in Kenya. *Journal of Agricultural Extension* 20, 53-65.

Bebe, B.O., Patience, M., Mshenga, M., Muthui, J.N., 2014. *Dairy insemination and replacement practices of smallholder farmers.* Policy Brief. Egerton University, Njoro.

Bebe, B.O., Udo, H.M.J., Rowlands, G.J., Thorpe, W., 2003. Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices. *Livestock Production Science* 82, 117-127.

Bebe, B.O., Udo, H.M.J., Thorpe, W., 2002. Development of smallholder dairy systems in the Kenya highlands. *Outlook Agr* 31, 113-120.

Burke, W.J., Myers, R.J., Jayne, T.S., 2015. A triple-hurdle model of production and market participation in Kenya's dairy market. *Am J Agr Econ* 97, 1227-1246.

Business Daily. 2016. Investors plan to pour billions into dairy industry. *Business Daily*, 23 February 2016. Available at: http://bit.ly/29Yj8Kq.

CCAFS, 2015. *Scaling up climate-smart dairy practices in Kenya through Nationally Appropriate Mitigation Actions.*

De Jong, M.J., J. van der Lee, and N.F. Makoni, 2015. *Kenya Market-led Dairy Program (KMDP). Strategic Review Report*. SNV Kenya Market-led Dairy Program, Nairobi.

De Vries, M., Yigrem, S., Vellinga, T., 2016 *Greening of Ethiopian Dairy Value Chains: Evaluation of environmental impacts and identification of interventions for sustainable intensification of dairy value chains.* Agricultural Transformation Agency (ATA), Ethiopia, Addis Ababa.

Dorward, A., Anderson, S., Bernal, Y.N., Vera, E.S., Rushton, J., Pattison, J., Paz, R., 2009. Hanging in, stepping up and stepping out: livelihood aspirations and strategies of the poor. *Dev. Pract*. 19, 240-247.

Dugué, P., Vayssieres, J., Chia, E., Ouedraogo, S., Havard, M., Coulibaly, D., Nacro, H.B., Fagaye, S., Sangare, M., Vall, E., 2011. *L'intensification écologique: réflexions pour la mise en pratique de ce concept dans les zones de savane d'Afrique de l'Ouest, Partenariat, modélisation, expérimentations: quelles leçons pour la conception de l'innovation et l'intensification écologique?* Cirad, p. 15 p.

Duru, M., Therond, O., 2014. Livestock system sustainability and resilience in intensive production zones: which form of ecological modernization? *Reg. Environ. Change* XX, 1-15.

Econexus, 2013. *A handful of corporations control world food production.* Econexus/Berne Declaration.

Ettema, F., 2015. *Status report medium scale farmers (MSFs) and commercial fodder producers (CFPs) agenda*. Landfort Adviesbureau/PUM Netherlands Senior Experts Program, Leeuwarden.

Firetail, 2013. *East Africa Dairy Development Project evaluation*. Heifer International, Nairobi.

FVM, 2010. *Smallholder Dairy Commercialization Programme. Final report: Development of a workable disease control strategy in cattle.* University of Nairobi, Faculty of Veterinary Medicine, Nairobi.

Herrero, M., Thornton, P., Notenbaert, A., Wood, S., Msangi, S., Freeman, H., Bossio, D., Dixon, J., Peters, M., Steeg, J., 2010. *Smart investments in sustainable food production: revisiting mixed crop-livestock systems.*

ILRI. 2008. *Markets that work: making a living from livestock. Annual Report 2007.* Nairobi: International Livestock Research Institute (ILRI).

Irwin, B., Campbell, R., 2015. *Market systems for resilience, Leveraging Economic Opportunities.* USAID, Washington.

Kang'ethe, E.K., M'Ibui, G.M., Randolph, T.F., Lang'at, A.K., 2007. Prevalence of aflatoxin M1 and B1 in milk and animal feeds from urban smallholder dairy production in Dagoretti Division, Nairobi, Kenya. East *African medical journal* 84, S83-86.

Kang'ethe, E.K., McDermott, B., Grace, D., Mbae, C., Mulinge, E., Monda, J., Nyongesa, C., Ambia, J., Njehu, A., 2012. Prevalence of cryptosporidiosis in dairy cattle, cattle-keeping families, their non-cattle-keeping neighbours and HIV-positive individuals in Dagoretti Division, Nairobi, Kenya. *Tropical Animal Health and Production*, 1-6.

Kang'ethe, E.K., Njehu, A., Karanja, N., Njenga, M., Gathuru, K., Karanja, A., 2010. Benefits and Selected Health Risks of Urban Dairy Production in Nakuru, Kenya. *African Urban Harvest*, 229-247.

Katothya, G., van der Lee, J., 2016 *Integrate and connect: Recommendations for KMDP's approach and role in knowledge exchange and skills development in the Kenyan dairy industry – Status report KMDP training and extensions approaches.* SNV Netherlands Development Organization, Nairobi.

KDB, 2015. *Kenya Dairy Board Annual Report and Financial Statements for the year ended 30 june 2014*. Kenya Dairy Board (KDB).

KDB. n.d. *Kenya Dairy Board website.* Available at: http://kdb.co.ke

KeBS. 2000. *Code of hygienic practice for milk and milk products*. Nairobi: Kenya Bureau of Standards.

Kilelu, C.W., Klerkx, L., Leeuwis, C., 2013. Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural Systems* 118, 65-77.

Kilelu, C.W., Klerkx, L., Leeuwis, C., 2016. Supporting smallholder commercialisation by enhancing integrated coordinationm in agrifood value chains: experiences with dairy hubs in Kenya. *Experimental Agriculture* 00, 1-19.

Kimanthi, K., 2015. Small farming paradise built on cow manure., *Daily Nation.*

Kristjanson, P., Waters-Bayer, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., Grace, D., MacMillan, S., 2014. *Livestock and women's livelihoods, Gender in Agriculture*. Springer, pp. 209-233.

Kruse, G., 2012. *The Chilling Hub Model and Social Capital in Dairy Value Chain Development.* Heifer International Kenya.

Kurwijila, L.R., Bennett, A., 2011. *Dairy development institutions in East Africa - Lessons learned and options.* FAO, Rome.

Langat, G., Tetsuhiro, M., Gonoi, T., Matiru, V., Bii, C., 2016. Aflatoxin M1 Contamination of Milk and Its Products in Bomet County, Kenya. *Advances in Microbiology* 6, 528.

Lawrence, F., Mutembei, H., Lagat, J., Mburu, J., Amimo, J., Okeyo, A., 2015. Constraints to use of breeding services in Kenya. *International Journal of Veterinary Science* 4, 211-215.

Lebacq, T., Baret, P., Stilmant, D., 2013. Sustainability indicators for livestock farming. A review. *Agron. Sustain. Dev*. 33, 311-327.

Makoni, N., Mwai, R., Redda, T., Zijpp, A.J.v.d., Lee, J.v.d., 2014. *White Gold : Opportunities for Dairy Sector Development Collaboration in East Africa.* Centre for Development Innovation, Wageningen UR, Wageningen, p. 205.

Mburu, J., Ojango, J., Kariuki, K., Baltenweck, I., 2011. *Constraints to the use of artificial insemination service and possible solutions.*

Mburu, L.M., Wakhungu, J.W., Kang'ethe, W.G., 2007. Characterization of smallholder dairy production systems for livestock improvement in Kenya highlands. *Livestock Research for Rural Development* 19, Article #110.

MoALF, 2010a. Kenya National Dairy Master Plan - *A situational Analysis of the Dairy Sub sector, Volume I.* Republic of Kenya, Nairobi.

MoALF, 2010b. *Kenya National Dairy Master Plan - Volume II, Action Plan and Implementation Strategy.* Republic of Kenya.

Montpellier Panel, 2013. *Sustainable Intensification: A New Paradigm for African Agriculture,* London.

Morton, J., Miheso, V., 2000. Perceptions of livestock service delivery among smallholder dairy producers: case studies from Central Kenya. *Livestock Research for Rural Development* 12, 2000.

Mulaa, M., Muyekho, F., Ajanga, S., Jones, P., Boa, E., 2004. *Napier stunt disease vector identification and containment of the disease on farm.* Kenya Agricultural Research Institute (KARI).

Muriuki, H., 2011. *Dairy development in Kenya.* Food and Agricultural Organization, Rome.

Muriuki, H., Omore, A., Hooton, N., Waithaka, M., Ouma, R., Staal, S.J., Odhiambo, P., 2003. *The policy environment in the Kenya dairy sub-sector: a review,* SDP Research and Development Report Smallholder Dairy (R & D) Project.

Muriuki, H., Thorpe, W., 2006. Smallholder dairy production and marketing in eastern and southern Africa: Regional synthesis, *The South-South Workshop on Smallholder Dairy Production and Marketing.* ILRI.

Mutinda, G., Baltenweck, I., Omondi, I., 2015. *Setting up sustainable dairy business hubs: A resource book for facilitators*. ILRI (aka ILCA and ILRAD).

Mwai, O., Hanotte, O., Kwon, Y.-J., Cho, S., 2015. African indigenous cattle: unique genetic resources in a rapidly changing world. *Asian-Australasian journal of animal sciences* 28, 911.

Mwirigi, J.W., Makenzi, P.M., Ochola, W.O., 2009. Socio-economic constraints to adoption and sustainability of biogas technology by farmers in Nakuru Districts, Kenya. *Energy for Sustainable Development* 13, 106-115.

Namanda, A.T., Kakai, R., Otsyula, M., 2009. The role of unpasteurized hawked milk in the transmission of brucellosis in Eldoret municipality, Kenya. *The Journal of Infection in Developing Countries* 3, 260-266.

Ndungu, T.W., Muliro, P.S., Omwamba, M., Oosterwijk, G., Jansen, A., 2016. Quality control of raw milk in the smallholder collection and bulking enterprises in Nakuru and Nyandarua Counties, Kenya. *African Journal of Food Science* 10, 70-78.

Ngigi, M., 2005. *The case of smallholder dairying in Eastern Africa*.

Njarui, D.M.G., Gichangi, E.M., Gatheru, M., Nyambati, E.M., Ondiko, C.N., Njunie, M.N., Ndungu-Magiroi, K.W., Kiiya, W.W., Kute, C.A.O., Ayako, W., 2016. A comparative analysis of livestock farming in smallholder mixed crop-livestock systems in Kenya: 1. Livestock inventory and management. *Livestock Research for Rural Development* 28.

Njenga, P., Mugo, F., Opiyo, J., 2012. *Youth and women empowerment through agriculture in Kenya.* Voluntary Service-Overseas (VSO-Jitolee). , Nairobi, Kenya.

Njoroge, L., Baltenweck, I., Ouma, R., Staal, S., Romney, D., 2004. Breeding services in Kenya: an examination of trends and factors predisposing adoption of artificial insemination technology, *East Africa Regional Animal Production Society Conference*, KARI headquarters, pp. 15-18.

Nyaanga, D., J. Gisemba, J. Khaemba, T. Vellinga, A. Vernooij, B. Wouters, F. ter Heegde and J. Libaisi. Forthcoming. *Manure management practices in small and medium-scale dairy farming systems in Kenya: A case study of Kisii, Meru, Kiambu and Uasin Gishu Counties*. Njoro: Egerton University.

Odame, H., Musyoka, P., Kere, J., 2009. *The agribusiness reports - Kenya: Maize, tomato and dairy, Agribusiness and innovation systems in Africa.* World Bank, Washington DC, pp. 89-132.

Odhong, C., Wahome, R., Vaarst, M., Kiggundu, M., Nalubwama, S.M., Halberg, N., Githigia, S., 2015. Dairy cattle management, health and welfare in smallholder farms: An organic farming perspective. *Journal of Organics.*

Okeyo, A.M., Kajume, J.K., Mosi, R.O., Okila, E.V.A., Gathuma, J.M., Kiere, S.M.N., Agumbah, G., Kuria, J.N., Chema, S., 2000. Artificial Insemination a bio-technological tool for genetic improvement of Kenyan dairy cattle herds: Historical perspective, current status, challenges and way forward in the next millennium. A Kenya Country Paper. Symposium on Dairy Cattle Breeding in East Africa: Sustainable Artificial Insemination Service, Kenya Agricultural Research Institute (KARI), Headquarters, Kiplagat Road, Nairobi. *Livestock Research for Rural Development*, 18. Retrieved September 10, 2014, from http://www.lrrd.org/lrrd18/5/chag18066.html

Olsson, I.A.S., Gamborg, C., Sandøe, P., 2006. Taking ethics into account in farm animal breeding: what can the breeding companies achieve? *Journal of Agricultural and Environmental Ethics* 19, 37-46.

Ommondi I A., K. K. Zander, S. Bauer and I. Baltenweck. 2016. Understanding farmers' preferences for artificial insemination services to increase dairy production. *Animal*, XX, 1-10.

Omore, A., Lore, T., Staal, S., Kutwa, J., Ouma, R., Arimi, S., Kang'ethe, E., 2005. *Addressing the public health and quality concerns towards marketed milk in Kenya*.

Omore, A., Muriuki, H., Kenyanjui, M., Owango, M., Staal, S., 1999. *The Kenya dairy sub-sector: a rapid appraisal.*

Ongadi, P., Wakhungu, J., Wahome, R., Okitoi, L., 2007. Characterization of grade dairy cattle owning households in mixed small scale farming systems of Vihiga, Kenya. *Age* 16.1.36 (2007): 16-08.

Orodho, A.B., 2006. *Country pasture/forage resource profiles.* Kenya.

Orregård, M., 2013. *Quality analysis of raw milk along the value chain of the informal milk market in Kiambu County, Kenya.*

Perfometer Solutions, 2013. *Study on the Kenyan animal feed and fodder sub-sectors: Trends in the Kenyan fodder sub-sector.* Perfometer Solutions/SNV Kenya/Netherlands Development Organization, Nairobi.

Perfometer Solutions. 2015. Interventions commercial fodder producers. In *Status Report Medium-scale farmers (MSFs) and commercial fodder producers (CFPs) agenda*. F. Ettema (Ed.), Leeuwarden: Landfort Adviesbureau/PUM Netherlands Senior Experts Program.

PPD Consultants, 2013. *Dairy Sector Policy Study and Capacity Needs Assessment of Stakeholder Associations.* SNV Netherlands Development Organization, Nairobi, Kenya.

PROIntensAfrica. 2016. *A literature review about experiences, research and innovation results obtained with a large spectrum of intensification pathways.*

Rademaker, C.J., Bebe, B.O., van der Lee, J., Kilelu, C., Tonui, C., 2016a. *Sustainable growth of the Kenyan dairy sector: a quick scan of robustness, reliability and resilience.* Wageningen University & Research, Wageningen Livestock Research Report 979

Rademaker, I.F., Koech, R.K., Jansen, A., van der Lee, J., 2016b. *Smallholder Dairy Value Chain Interventions: The Kenya Market-led Dairy Program (KMDP) - Status report.* Wageningen, Centre for Development Innovation, Wageningen University and Research centre, Report CDI-16-018

Reardon, T., Boughton, D., Tschirley, D., Haggblade, S., Dolislager, M., Minten, B., Hernandez, R., 2015. Urbanization, Diet Change, and Transformation of the Downstream and Midstream of the Agrifood System: Effects on the Poor in Africa and Asia. *Faith & Economics* 66, 43–63.

RoK. (Republic of Kenya). 2007. *Kenya Vision 2030. The Popular Version*. Nairobi: Republic of Kenya. Available at: http://www.vision2030.go.ke/wp-content/uploads/2015/06/Popular_Version1.pdf.

RoK. (Republic of Kenya). 2010. *The Constitution of Kenya*. Revised Edition 2010. Nairobi: Republic of Kenya. Available at: http://www.kenyalaw.org/lex//actview.xql?actid=Const2010.

Romney, D., Njubi, D., Njoroge, L., Nyangaga, J., Waithaka, M., Muriuki, H., Wokabi, A., Mwangi, D., Staal, S., 2004. Understanding the role of dairy in smallholder systems and the effect of intensification, *Ninth KARI (Kenya Agricultural Research Institute) annual scientific conference and agricultural research forum*, Nairobi, Kenya.

Ruto, E., Garrod, G., Scarpa, R., 2008. Valuing animal genetic resources: a choice modeling application to indigenous cattle in Kenya. *Agr Econ-Blackwell* 38, 89-98.

Sandøe, P., Nielsen, B.L., Christensen, L.G., Sørensen, P., 1999. Staying good while playing God-The ethics of breeding farm animals. *Animal Welfare* 8, 313-328.

Seré, C., Steinfeld, H., Groenewold, J., 1995. World livestock production systems: current status, issues and trends, In: Gardiner, P., and C. Devendra, eds. *Global Agenda for Livestock Research: Proceedings of Consultation on Global Agenda for Livestock Research*, Nairobi (Kenya), 18-20 Jan 1995. ILRI, Nairobi, Kenya. ILRI (aka ILCA and ILRAD).

SNV Kenya, 2015. *SNV Kenya Positioning Paper Dairy Sector* - KMDP. SNV Netherlands Development Organization, Nairobi.

SoG. 2015. Forget cattle dips, we will spray your animal for Sh30. *Seeds of Gold (SoG) rubric in Daily Nation 3 July 2015*. Available at: http://www.nation.co.ke/business/seedsofgold/Forget-cattle-dips-we-will-spray-your-animal-for-Sh30/- /2301238/2774394/-/g820s7/-/index.html.

Staal, S.J., Nin Pratt, A., Jabbar, M., 2008a. *Dairy development for the resource poor. Part 2: Kenya and Ethiopia.* Dairy development case studies.

Staal, S.J., Pratt, A.N., Jibbar, M., 2008b. *Dairy Development for the Resource Poor - A comparison of Dairy Ploicies and Development in South Asia and East Africa, A Living from Livestock,* Pro-Poor Livestock Policy Initiative, PPLPI Working Paper no. 44.

Sulo, T., Chepng'eno, W., Tuitoek, C.C., Lagat, J., 2012. Assessment of Youth Opportunities in the Dairy Sector in Uasin Gishu County-Kenya. *Journal of Emerging Trends in Economics and Management Sciences* 3, 332.

Technoserve Kenya, 2008. *The Dairy Value Chain in Kenya.* East Africa Dairy Development Program.

Tegemeo, 2016. *Report of a study on assessing the costs of production structures in dairy systems in Kenya.* Tegemeo Institute of Agricultural Policy and Development, Egerton University, Nairobi.

Udo, H., Weiler, V., Modupeore, O., Viets, T., Oosting, S., 2016. Intensification to reduce the carbon footprint of smallholder milk production: fact or fiction? *Outlook Agr* 45, 33-38.

Udo, H.M.J., Aklilu, H.A., Phong, L.T., Bosma, R.H., Budisatria, I.G.S., Patil, B.R., Samdup, T., Bebe, B.O., 2011. Impact of intensification of different types of livestock production in smallholder crop-livestock systems. *Livestock Science* 139, 22-29.

van de Steeg, J.A., Verburg, P.H., Baltenweck, I., Staal, S.J., 2010. Characterization of the spatial distribution of farming systems in the Kenyan Highlands. *Applied Geography* 30, 239-253.

van der Lee, J., Helder, J.J.A., Groot, J.J., 2014a. Driving innovations in the agri-food system. In: Achterbosch, T., M. van Dorp, W. van Driel, J. Groot, J. van der Lee, A. Verhagen and I. Bezlepkina: *The food puzzle: pathways to securing food for all*, Wageningen UR., pp. 64-67.

van der Lee, J., Zijlstra, J., Wouters, A.P., van Vugt, S.M., 2014b. *Milking to Potential : Strategic Framework for Dairy Sector Development in Emerging Economies. Discussion paper*. Wageningen University & Research centre, Wageningen, p. 30.

Wambugu, S., Kirimi, L., Opiyo, J., 2011. *Productivity trends and performance of dairy farming in Kenya.* Tegemeo Institute of Agricultural Policy and Development, Egerton University, Nairobi.

WEF. n.d. *Women Enterprise Fund (WEF).* Available at:http://www.wef.co.ke/index.php/about-us/wef-profile/our-mission.

Weiler, V., Udo, H.M., Viets, T., Crane, T.A., De Boer, I.J., 2014. Handling multi-functionality of livestock in a life cycle assessment: the case of smallholder dairying in Kenya. *Curr.Opin.Sust.* 8, 29-38.

Wieczorek, A., Hekkert, M.P., 2012. Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. *Science and public polity* 39, 74-87.

Wiggins, S., Keats, S., 2013. *Leaping and Learning: Linking smallholders to markets in Africa.*

Yard, E.E., Daniel, J.H., Lewis, L.S., Rybak, M.E., Paliakov, E.M., Kim, A.A., Montgomery, J.M., Bunnell, R., Abudo, M.U., Akhwale, W., 2013. Human aflatoxin exposure in Kenya, 2007: a cross-sectional study. *Food Additives & Contaminants: Part A* 30, 1322-1331.

Appendix 1 SWOT analysis for Kenyan dairy farming

	Strengths	Weaknesses	Opportunities	Threats
Economic sustainability	- Strong history of keeping cattle; large population of quality dairy genetics - Widespread market distribution network for milk and dairy products - Well-established sector with diverse input, service and outputmarkets - Diverse financial services (banks, MFIs, SACCOs) for dairy - Mobile platforms for money transfer and integrated money deduction widely established	- Poor dairy herd management skills in feeding, breading and health - Lack of entrepreneurship/ commercial approach to dairy farming - Poor access to and quality of inputs and services (feeds, AI, extension, equipment) - - Unfavourable terms of credit facilities for dairy enterprises - DVC fragmenta-tion with low supplier loyalty - High cost of production & high milk losses in the chain lead to high consumer prices - Low milk quality - Limited data availability and poor record keeping	- Growth in processors with incentives for milk suppliers - Growing domestic and regional markets - Growth in commercial and on-farm fodder production and conservation, fodder contracting services and feed rationing at farm level - Increased demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs) - Provision of embedded / bundled services by DFCSs to reduce side-selling - 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 - Strong national and county government support to and investments in dairy	- Decreasing farm sizes - Public concerns with milk quality (aflatoxin, antibiotics, microbial) - Processor oligopoly - High fodder and animal disease and zoonosis incidence (ECF, Food & Mouth Disease, tuberculosis, brucellosis) - High energy costs - Water scarcity and unsecured water access - Danger of market distortions through donor and government investments - Cheap milk imports from Uganda and reduction of 60% import levy on dairy products threaten market for domestic milk - Reliance on imported feed ingredients - Poor quality of feed resources imported from neighbouring country - Low attractiveness of sector for foreign input suppliers - Uncoordinated and inefficient QA systems for feed, fodder and milk - unethical practices by feed suppliers and milk traders - Low compliance with quality and safety standards and statutory levies -Outbreaks of transboundary animal diseases (Food & Mouth Disease, Rift Valley ever)
	Strengths	**Weaknesses**	**Opportunities**	**Threats**
Environmental sustainability	- Mixed farming systems integrating compost, manure and nutrient recycling - Favourable agroclimatic conditions for dairy production -Large population of indigenous cattle and camels for milk production	- Low sensitivity to environmental impact of dairy production and processing - Limited attention to reduction of greenhouse gas emissions -Low sensitivity to conservation of indigenous cattle for their unique product attributes	- Promote renewable energy, e.g. biogas from dairy manure - Promote organic fertilizer use - Increase support for GHG mitigation in dairy sector through development of dairy national appropriate mitigation actions - Awareness-building of environmental issues through national education system	- Environmental degradation and climate change impacts: - Increased risk of disease outbreaks - Poor manure management capacities in landless farms - Loss of indigenous breeds and farm animal genetic diversity -Loss of biodiversity in pasture and fodder species for cattle feeding --Outbreaks of fodder and pasture diseases; invasive weeds threatening fodder production

	Strengths	Weaknesses	Opportunities	Threats
Social sustainability	- Dairy is key livelihood activity (direct/ indirect) for many households - Increasing support for DFCS and farmer group development to strengthen ownership, trust and broader community development - Tradition of livestock (cattle) keeping and milk consumption	- Low bargaining power / negotiation position of smallholders - Low attraction of farming for youth; poor access to production factors for youth and women - Insufficient entrepreneurial approach, with inadequate dairy farming practices - Uncontrolled drug prescription and usage - Low compliance with KeBS's Code of Practice for hygienic milk production and handling (KeBS, 2000) - Uncoordinated transition of service provision from public to private actors resulted in gaps in AI and veterinary services - Extension services are weak: service liberalization has not attracted substantial private sector participation, is not linked to private industry development and has not attracted coordinated private sector and farmer group participation - Lack of access to ICT services, especially for on-farm and DFCS management	- Restructuring of the role of KDB to play a larger role in regulation and compliance - Regulation and QA of private investments - Match-making role for county governments to link input suppliers to producers - Contract enforcement mechanisms for milk procurements between farmers, CBEs and processors - Increasing sense of urgency to address quality and loyalty issues in the DVC - Enforcement of regulations on drug prescription and use - Development of QA systems for feed, fodder and milk - Training of key players in the raw milk chain to improve sanitation and quality; of formal chain actors on milk handling with respect to QA system - Experimentation with bundled input and service provision models by private and third sector actors - Private T&E service provision farmers to improve on current farming and milk-handling practices PDTCs, private advisory services, training calendars - Inclusion of training in soft skills on training farms and mid-level curricula	- Actors have insufficiently articulated and shared vision for the sector and no effective and sustainable sector platforms to drive sector vision and agenda - Weak governance and management in cooperative sector, resulting in malfunctioning and collapse - Weak organizational capacity of farmer associations prevents effective lobbying and investment facilitation - Increased subsidization keeps smallholders uncompetitive, reducing their capacity to transition to commercial farming or changing livelihoods - High zoonosis incidence and poor milk quality threatens public health - Increasing regulation of unprocessed milk chain may drive up consumer prices or drive down farm gate prices - Sector support interventions by the GoK and county governments subject to political goodwill - Lack of trust along the DVC; mutual processor-cooperative-farmer contract violation; feed manufacturing and trade malpractices - Poor compliance with quality and safety requirements - Concentrated processor segment - Delayed approval of feed and breeding policies at national level - No official accreditation for practical training through PDTCs, making trainees unrecognizable in the market - Weak dairy research, especially for sector policy and productivity; research not really client-oriented; weak linkages between research institutes and dairy industry

Appendix 2

Key risks, stresses & shocks and potential SI coping strategies - related to sustainable intensification of dairy farming in Kenya

Green: topics and options surfacing in this study;
Orange: additional topics and options as considered relevant according to authors
[...] Considered to be less relevant in Kenya

- Most important

Threats	Risks, stresses, shocks	Potential SI coping strategies for low intensity farmers	Potential SI coping strategies for medium intensity farmers	Potential SI coping strategies for high intensity farmers	Potential SI coping strategies other chain and sector actors
Ineffectiveness of farming to provide reasonable livelihood to farmers and/or to feed urban population	Low profitability due to: - High cost of production; high milk losses in chain; high consumer prices; low milk quality - Inadequate farmer skills leading to poor animal husbandry, breeding, disease control and feeding practices - Lack of entrepreneurship/ commercial approach to dairy farming - Lack of interest of public and private actors to genuinely invest in smallholder farming - Subsidization keeping smallholders uncompetitive, reducing their options to transition to commercial farming or to change livelihoods - Lack of data on cost of production due to record keeping not being common practice among farmers	SI by: - Use of crossbreeds (Bebe et al., 2003) - Use of dual-purpose cereals for food and fodder (Romney et al., 2004) - Improved use of crop residues	SI by: - Upgrading breeds to dairy grade cattle - Choice of feed & fodder crops - Changes in input levels (costs) – feeding, breeding, health care, technology; - management practices - Use of advisory services	SI by: - Purposeful breeding - Feed rationing – grass, grain and supplements - Use of veterinary services, advisory services and record keeping to improve management - Entry of young farmers willing to commercialize dairy (inheriting or leasing land) - Use of ICT options to enhance data collection and record keeping	- Facilitate entry of young farmers by training & extension and easing access to land and credit
Employment outside farming more appealing	- New generation finds farming not appealing		- Use of new technology and practices	- Use of new technology and practices	- Improve access to production factors for youth and women - Support innovation in ICT and technologies for dairy
Market instability	- Processor oligopoly / low bargaining power of smallholders - Lack of trust along DVC actors; mutual processor-cooperative-farmer contract violation;	- Vary level and timing of marketable surplus / storage	- Feed ration formulation and dry season feeding to reduce seasonality	- Feed ration formulation and dry season feeding to reduce seasonality and optimize	- Fodder contracting services - Embedded input and service provision by private and third sector actors:

	- Feed manufacturing and trade malpractices - Danger of market distortions through donor and government investments - Cheap milk imports from Uganda and reduction of 60% import levy on dairy products threaten market for domestic milk - Increasing regulation of unprocessed milk chain may drive up consumer prices or drive down farm gate prices	- Multiple clients	and optimize production	production - Commercial and/or on-farm fodder production and conservation - Dairy farm and commercial fodder farm development in regions with available land - Contracting out fodder production and preservation	DFCSs, PDTCs, private advisory services, ISP contracting - Development of QA systems for feed and fodder - Development of milk QA systems - Processors to increase incentives for stable supply of quality milk - Contract enforcement mechanisms for milk procurements between farmers, DFCSs and processors
	-	-	-	-	-
Injudicious governance of land, water and energy	Land - Loss of soil quality (physical, chemical, biological) - Scarcity of land / land use rights - Low sensitivity to environmental impact of dairy production	- Mixed farming systems with integrated farming practices - Improved use of commons	- Promote organic fertilizer use - Promote fodder legumes	- Promote organic fertilizer use - Promote fodder legumes - Leasing of land - Purchase of fodder	- Facilitate leasing of land - [Land titling] - Awareness-building of environmental issues through national education system
	Water - Scarcity of water resources / user rights - [Decline in water quality]	- Conservation agriculture	- Water use management - Cover crops - Drought-tolerant (fodder) crops	- Water harvesting - Irrigation - Use of drought-tolerant (fodder) crops	
	Energy - Scarcity of energy resources - Scarcity of renewable energy resources / dependency on fossil fuels	-	- Promote green energy (biogas from dairy manure; solar, hydro, wind energy)	- Promote green energy, e.g. biogas from dairy manure; solar, hydro, wind energy	- Promote green energy, e.g. biogas from dairy manure; solar, hydro, wind energy
Injudicious introduction and/or utilization of chemical fertilizer, pesticides & drugs	Chemical residues in produce - Public concerns with milk quality (aflatoxin, antibiotics, microbial) - unethical practices by feed suppliers and milk traders (and uncoordinated and inefficient QA systems for feed, fodder and milk; low compliance with KeBS's Code of Practice for hygienic milk production and handling Chemical residues in environment	- Limit use of chemical inputs	- Judicious use of pesticides, drugs, chemical fertilizers	- Judicious use of pesticides, drugs, chemical fertilizers	- Training of DVC actors on milk handling and QA system - Training of raw milk chain actors to improve sanitation and quality - Development of QBMPS - Enforcement of regulations on drug prescription and use
Nutrient imbalance due to import/ export/ loss of nutrients	Nutrient depletion / eutrophication - Increasing manure management issues in landless farms - Increasing use of chemical fertilizer	- Mixed farming systems, integrated farming practices - Increase use of crop residues and organic fertilizer	- Integrate fodder crops in farming practices - Promote organic fertilizer use (compost, manure, crop residues) - Integrate legumes with fodder to increase soil and plant nitrogen supply from natural sources	- Improve manure management - Improve nutrient management	
Population dynamics - growth - urbanization	Urban-rural divide - Decreasing farm sizes - Food products not socially acceptable - Unfavourable image of agriculture - Appeal of urban life makes rural areas unattractive	- Vary acreage cropped - On-farm food preservation	- Vary acreage cropped & number of animals kept - Become more market-oriented - Use of technology	- Become more market-oriented - On-farm processing and other value addition activities - Use of technology	- Family planning interventions
Climate change	Climate - greenhouse gas and acidifying emissions - (more) unfavourable climatic conditions	- Agrobiodiversity in (seed/breed/species) stock	- Protection against floods, droughts, epidemics		- Increase support for GHG mitigation in dairy sector through development of dairy national appropriate mitigation

	- natural disasters - Increased risk of disease outbreaks - Necessity to change crop choice, management - Limited attention to reduction of greenhouse gas emissions	- (planting & growing season, species)			actions - Awareness-building of environmental issues through national education system
Natural/man-made disasters	Loss of assets and productivity due to - High animal disease and zoonoses incidence (ECF, food & mouth disease, tuberculosis, brucellosis) - Uncontrolled drug prescription and usage - Invasive weeds threatening fodder production - High zoonosis incidence and poor milk quality threat to public health - High fodder disease incidence - Loss of indigenous breeds - loss of (seed/breed) stock - loss of (agro)biodiversity - sickness & death - see above under land, water, energy	- Agrobiodiversity in (seed/breed) stock	- Farm design - Community support - Public support/aid - Use of insurance - Vaccination - Savings - Contracts		
Inadequate socio- economic policy	- Poor enforcement of quality and safety requirements - Feed policy developed at national level not yet approved - Lack of access to ICT services, especially for on-farm and DFCS management - Sector support interventions by the GoK and county governments subject to political goodwill - Road infrastructure, transport facilities not up to par in all areas; high cost of power	- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs) - Collective infrastructure creation & maintenance	- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs) - Collective infrastructure creation & maintenance	- Articulate demand for inputs and services (AI and animal genetics, animal health, heifers, vaccines, drugs)	- Diversify input and services markets - Public support to and investments in the dairy industry - Restructuring of the role of KDB to play a larger role in regulation and compliance / based on revised Dairy Industry Act (2012)
Inadequate policies on training, extension, research, innovation support	- No official accreditation for practical training through PDTCs, making trainees unrecognizable on the market - Weak dairy research, especially for sector policy and productivity; research not really client-oriented; weak linkages between research institutes and dairy industry - Uncoordinated transition of service provision from public to private actors resulted in gaps in AI and veterinary services - Extension services are weak: service liberalization has not attracted substantial private sector participation, is not linked to private industry development and has not attracted coordinated private sector and farmer group participation - Insufficient entrepreneurial approach, inadequate dairy farming practices - Limited data availability and poor record keeping in sector	- Collective input purchasing and output marketing mechanisms	- Collective input purchasing and output marketing mechanisms		- Department of Technical and Vocational Education and Training can provide a regulatory framework and give guidelines to the PDTCs for practical training - Promote mobile platforms for money transfer and integrated money deduction widely established - Inclusion of training on entrepreneurial and soft skills on training farms and mid-level curricula - Knowledge linkages with international companies and institutions - Farm advisory services
Inadequate collective action	- Weak governance and management in cooperative sector, resulting in malfunctioning organizations - Actors have insufficiently articulated and shared vision for the sector - Lack of effective and sustainable platforms to drive sector agenda - Weak organizational capacity of farmer associations prevents effective lobbying and investment facilitation - Loss of social cohesion in farming community				- DFCS and farmer groups contribute to sense of ownership, trust and broader community development

SWOT elements not fitting well in this scheme:

- Favourable agroclimatic conditions for dairy production
- Dairy is key livelihood activity (direct/ indirect) for many households, Strong history of keeping cattle and milk consumption; large livestock population with availability of quality dairy genetics
- Growing domestic and regional markets; widespread market distribution network for milk and dairy products
- Poor access to and poor quality of inputs and services (feeds, AI, extension equipment, etc.);
- Diverse financial services (banks, MFIs, SACCOs)offering financial products, but few appropriate financial products for dairy sector (rigid conditions and high interest);
- Policy opportunities: Beneficial tax regime for investment in processing facilities and feed ingredients; regulation and QA of private investments
- Increasing sense of urgency to address quality and loyalty issues in the DVC

Source: This framework was developed by authors based on (Duru and Therond, 2014); (Irwin and Campbell, 2015); (Lebacq et al., 2013)

PROIntensAfrica

Towards a long-term Africa-EU partnership to raise sustainable food and nutrition security in Africa

Wageningen Livestock Research
P.O. Box 338
6700 AH Wageningen
The Netherlands
T +31 (0)317 48 39 53
info.livestockresearch@wur.nl
www.wur.nl/livestock-research

Wageningen Livestock Research
Report

The mission of Wageningen University and Research is “To explore the potential of nature to improve the quality of life”. Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 10,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.