

Supplementary material 1

Basic Data on Study Areas

Table A shows basic data on dairy production as compared to crop production and other livestock. Figures A and B give a schematic representation of dairy value chains in both countries.

Table A. Basic agricultural sector data for the study areas

	Kenya (2014 data)		Ethiopia (2014–15)	
	Nandi	Nyandarua	Arsi	East Shoa
Population	753,000	659,848	2,637,657	1,356,342
Arable land (ha)	193,020	201,100	818,132	526,211
Area cropped (ha, excl. tea 1))	104,916	81,929	631,736	473,124
Livestock (heads)				
Dairy cattle	251,455	314,810	2)	
Zebu cattle	45,584	30,620	Cattle	2,454,324
Small ruminants	70,048	426,027	Small ruminants	2,356,854
Poultry	605,097	445,145	Poultry	2,188,076
Equines	n.a.	10,633	Equines	678,711
Rabbits	n.a.	44,670		330,603
Pigs	145	879		
Milk production (Million kg)	84	226	Milk production 2)	136
Agricultural turnover (Million KES)			(Million kg)	44
Milk	2,537	7,216		n.a.
Potatoes	400	7,800	Cereals	1,369
Maize	2,700	421	Pulses	134
Other grains	12	232	Oilseeds	23
Beans	1,900	48	Vegetables	12
Tea *)	n.a.	--	Root crops	53
Other	276	1,769	Permanent crops	11

Sources: [39,40]

Source: www.csa.gov.et

1) Tea statistics are maintained at national level

2) Data for 2013–2014

The dairy sector in both countries is undergoing significant change. In Kenya, positive changes occur in all three domains. At *institutional level*, attention is growing for sector competitiveness in relation to other members of the East African Community and for milk quality, partly fueled by media attention for safety of milk for consumers. *Value chain upgrading* examples include initiatives where cooperative companies and processors improve supplier loyalty through chain integration, e.g. by improved contracting and embedded services; increased participation of multinational dairy companies works as stimulus; and farmers circumvent failing cooperatives by forming self-help groups that sell bulk (aggregated) milk to processors. Meanwhile, a number of innovations occur in the informal market¹: pasteurized milk is sold through bulk dispensers in retail outlets that offer processed milk at two-thirds the price of packed milk, and traders rent processing capacity to sell unpacked pasteurized milk to bulk dispensers. At farm level, *technical upgrading* is increasing, including adoption of planted forage, forage preservation, and zero-grazing. In ‘dairy cluster’ Nyandarua (and to some extent in Nandi North), farmers have been aware of these upgrading options since the 1980s, but so far only the ‘serious farmers with capital’ invest in them; wider adoption is limited by uncertain milk prices.

Table A shows that, with similar populations and arable land areas, Nyandarua milk production was nearly three times that of Nandi, of which an estimated one-third is processed. Of

¹ Bebe, Bockline Omedo, Ruth Njiru, Jan van der Lee, Catherine Kilelu. 2019 Assessing operational costs, consumer perceived risks and quality of milk from vending machine retail innovation in Kenyan urban markets (forthcoming)

the 193,000 hectares of arable land in Nandi, much was under commercial tea plantations. The significantly higher milk productivity and dairy focus in Nyandarua over Nandi is enabled by larger farm sizes (see Table 3), higher percentages of improved breeds, larger number of providers of pre- and post-production services, and advantages in the enabling environment. Dairy farms in Nyandarua and Nandi South are overwhelmingly smallholdings, even though average farm size in Nyandarua is more than triple that in Nandi South in terms of hectares and double in terms of dairy cows; Nandi North has more non-dairy farmers (25% of farms) and more medium- and large-scale farms (24% of dairy farms, mostly owned by the descendants of the original Nandi population, while smaller farms are owned by post-independence settlers). In Nyandarua, average farm size is larger, but VCAI showed similar differences between early arrivals (West of Ol Kalou) and post-independence settlers (East of Ol Kalou).

The situation in LaLc Arsi cluster shows that a much higher than average percentage of improved breeds (Table 3) does not compensate for the bottlenecks in dairy market access and the competitive edge of grain production due to an improved input and service package.

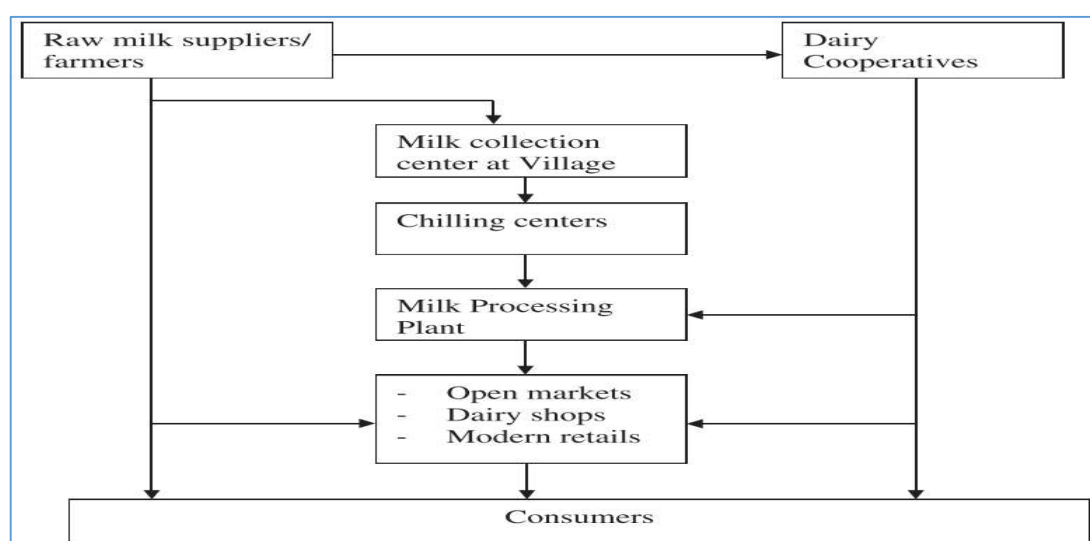


Figure A. Dairy value chain structure in the greater Addis Ababa milkshed, Ethiopia. Source: [17]

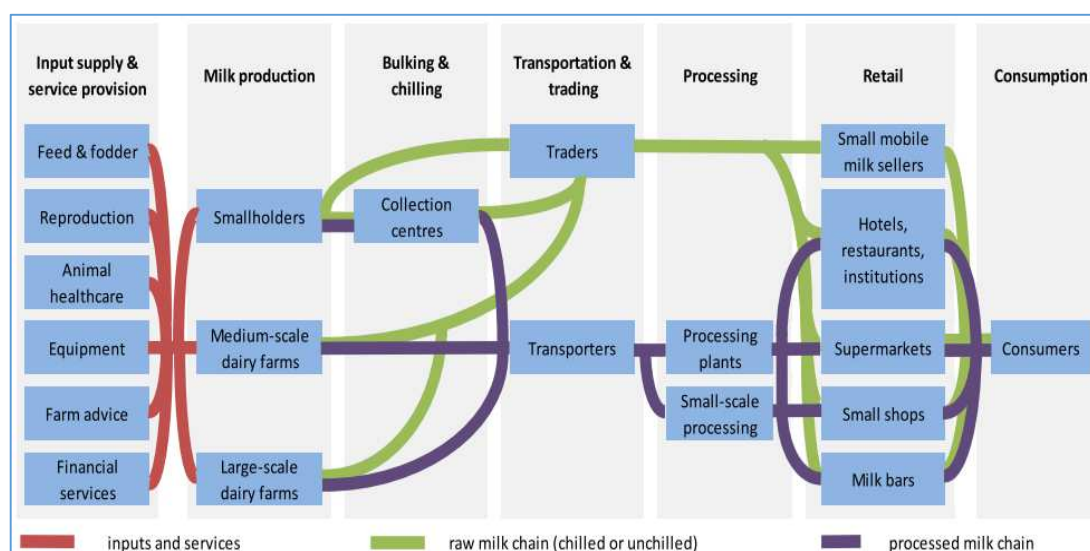


Figure B. Overview of the dairy value chain in Kenya ².

² Rademaker, C.J.; Bebe, B.O.; van der Lee, J.; Kilelu, C.; Tonui, C. *Sustainable Growth of the Kenyan Dairy Sector: A Quick Scan of Robustness, Reliability and Resilience*; Wageningen University & Research, Wageningen Livestock Research Report 979: Wageningen, The Netherlands, 2016.

Supplementary material 2

Cluster-wise Description of Upgrading Dynamics

This section describes in more detail the dairy upgrading dynamics, summarized in Table 2, for the five clusters in Ethiopia and Kenya.

L_aL_c Arsi cluster, Ethiopia—Of the five clusters, Arsi is least progressed in *technical upgrading* of the ‘typical’ semi-subsistence mixed crop–livestock systems to more market-oriented systems (see Table 3 and Figure 3). In this area, which is particularly suited for dairy and has a long tradition of multi-functional cattle husbandry, transition from grazing land to cereal cropping was still evident very recently; farmers feel the pressure to change farming practices and reduce their number of cattle and sheep. Compared to the national average of 5.7%^[3] dairy cows of improved breeds and 1.8% cattle of improved breeds^[4], the proportion of improved breeds in the herd of interviewed dairy farmers is high (55%), primarily so in urban farms. This can be attributed to the crossbred bull and AI distribution of the breeding center at Asella University, which has been active since the 1950s. This high proportion of crossbreds is despite the fact that due to poor road access, *value chain upgrading* to marketing outside the cluster never happened—farmers and cooperatives only market some butter to Southern Nations and Oromiya regions in addition to local sales of milk and traditional dairy. Nevertheless, at 31% the proportion of milking cows in the herd is low, reflecting other uses including draft power and heifer breeding. Collection by a processor from Adama was quickly discontinued due to milk quality issues. The taboos on sale of fresh milk and dairy products are only gradually losing their impact as milk undergoes commodity individuation [47]. Because of these marketing constraints, dairy is primarily concentrated around the towns (i.e. consumer centers). Breeding heifers for sale and fattening calves and sheep are important livestock activities (see Table 3) and enable private feed sellers to have a presence. In terms of *institutional upgrading*, interviews showed that by the time main roads improved in the early 2010s, the public extension system’s promotion of improved potato and grain variety packages, along with accompanying inputs and services, had already caused the balance to shift in favor of cash crops. Where roads and electricity are improved, more off-farm activities emerge. Various technologies have gradually gained popularity, starting with fertilizer (since the late 1980s), then agro-chemicals (since the late 1990s), then mechanization (since the late 2000s). The contracted equipment is owned by the urban elite, who invest in agriculture due to profitability of cash crops. Government-promoted dairy cooperatives primarily cater to local demand and are unable to offer significant additional services (Table 4). Hence, farmers largely depend on general public support services and their (subsidized) inputs but are unsatisfied with service quality. Some exceptional extension officers, additional veterinary and AI services provided by off-duty government staff, and one-off development projects have only a small effect on this situation.

L_aH: East Shoa cluster, Ethiopia—Being located just south-east of the capital offers this cluster good access to end markets, including for dairy, but also results in competition for space with infrastructure projects (e.g. express roads, railways); industry; and agribusiness, notably flower farms. Ongoing intensification leads to specialization, from food and cash crops to horticulture (40% non-dairy farms) and intensive livestock-keeping. This *technical upgrading* (Table 3) occurs especially in town. Dairy being maintained on larger rather than smaller farms could be an explanation for the larger farm size compared to those in the L_aL_c Arsi cluster, despite pressure on land. Adoption of technologies and innovations generally preceded that in L_aL_c Arsi cluster by about ten years, due to proximity to end markets and information being available from livestock research and education

³ CSA (2017) data are inconclusive in this respect; they mention 674,765 exotic cows out of a total of 11,833,179 “milking cows” of which 7,155,114 are “dairy cows” that are “used for milk”.

⁴ CSA. Agricultural sample survey 2016/17 [2009 E.C.], volume ii: Livestock and livestock characteristics (private peasant holdings) In Statistical bulletin 585, Central Statistics Agency, Federal Democratic Republic of Ethiopia: Addis Abeba, 2017.



institutes. For villages with good road connections, *value chain upgrading* over the past two decades, involving establishment of processing plants (including a cooperative plant), has made farmers less dependent on traders (Table 4). The large seasonal variation in milk prices and high feed prices discourage farmers, despite high average milk prices. Processors offer virtually no input services; these have to be obtained from the open market and from public providers. Due to the unreliability of government AI and veterinary services, farmers turn to private providers, who are mostly off-duty government staff. Feed suppliers abound, but so do poor quality feed and high prices. Little *institutional upgrading* is evident. Farmers complain about general lack of public support in terms of regulations for dairy and supply of industrial feeds and forage seeds. Access to finance for dairy is very limited and limits dairy expansion. Where possible, farmers rely on community groups, 'ekub' and 'edir', for mutual support on labor and capital. High prices of production factors and inputs and low availability of support services are seen as serious threats to the sustainability of dairy farming.

L_aH_c Nandi South cluster, Kenya—In Nandi South dairy, has clearly lost out to tea and horticulture. Dairy was strong until the early 1990s, even though farmers struggled with introducing exotic breeds due to tick-borne diseases such as East Coast Fever. After the collapse of the public dairy support services following the Structural Adjustment Plans of the World Bank and IMF in the early 1990s, most cooperatives collapsed, along with the state processor KCC [48]. In effect, this resulted in *technical and market downgrading*. When the Cheptumo Tea Factory in the study area offered a good service support package, farmers shifted to tea: 30–40% of farmers have planted tea over the past four decades. The small farm sizes (<1 ha, Table 3) only allow for certain combinations of high-value crop and livestock production, i.e. tea, horticulture, and market-oriented livestock (see Table 3). For cultural reasons, most farmers prefer to keep a few cows, even if they lack the space. The surplus milk is collected and marketed in Western Kenya by traders. The single small cooperative that was revived caters to local demand and sells to traders.

The transition to horticultural crops (vegetables and roots/tubers/bananas) and perennials (tea and fruit trees) is ongoing and applies to the large majority of farmers. Moreover, since the early 2010s nearly half of the farmers have reduced the size of their cow herds in favor of smaller livestock such as small ruminants, poultry, and rabbits. Tea plantations offer smallholders opportunities for casual labor. Around Kaptumo town more market-oriented, specialized dairy farmers, who take pride in breeding and good dairy management resulting in higher yields, plant forage and contract AI providers and veterinarians. Except for these 'serious' farmers with higher inputs and higher yields, the cluster shows low investments in forage production, breeding and health care, and productivity remains low. The low demand for services results in low market development efforts by input suppliers and service providers and low farmer satisfaction. In the remote parts of the cluster where little tea is grown, some farmers focus on fattening and some on breeding of heifers.

H_aH_c Nandi North cluster, Kenya—While issues of small farm sizes, disease threats, tea promotion, and the 1990s collapse of cooperatives apply to Nandi North as well, the dairy upgrading situation is markedly different from that in Nandi South. The main contributors to this appear to be the higher proportion of medium-scale and large farms, resulting in slightly larger farm sizes (average 1.56 vs 0.83 ha, Table 3), and the presence of some stronger cooperatives. Larger farm sizes cause less pressure to replace maize with high-value, short maturation crops and livestock (about 60% of farmers as compared to 85% in Nandi South) and allow for multiple crop–dairy combinations: sugarcane or fruit trees next to tea. Individual farmer practices depend on their preferences and resources, especially labor and land. While around 20 out of 30 dairy cooperatives have collapsed since the late 1990s, the stronger dairy cooperative societies such as Tanykina, Lessos, and Kabyet are now able to effectively collect larger volumes of milk. *Value chain upgrading* is evidenced by their offer of pre- and post-production service packages. These include agro-veterinary input shops and loans. They thus attempt to offer a competitive alternative market to the traders mentioned above. Three processors collect milk. One of them has started to integrate input supply and service provision such as credit linkages in its supply chain. In the dry season, competition for milk is fierce and cooperatives often lose out to traders. Price fluctuations and inconsistent payment conditions in



the chain have a negative effect, resulting in much market uncertainty for farmers. While traders ship milk to Western Kenya, the cooperatives sell to processors in Eldoret (Uasin Gishu County) and further afield. Cooperatives and the Kenya Dairy Farmers Federation are talking with Nandi County authorities about establishment of a dairy plant in the county, but viability is still uncertain. Although Nandi people are reportedly slow adopters of innovation, interviewees were positive about (resource-endowed) dairy farmers' adoption of new practices and approach to 'dairy as business', but also lamented the recent slump in milk prices as a threat to the sector. Interviewees were rather negative about *institutional upgrading* in terms of the county's policy support for dairy and its actual implementation, including vaccination, extension, and road maintenance. This was also reflected in farmers' information sources.

HaHc Nyandarua cluster, Kenya—This is clearly the most market-oriented dairy cluster of the five, in terms of volumes marketed, number of actors and input–output linkages, and competition between service providers. The high altitudes and cool weather favor dairy, potatoes, and cabbages over other crops—that is, if prices do not decline further. Spatial variation within the county stems from diversity in rainfall patterns, in farm sizes resulting from land allocation policies following independence, and in inherited household resources. Compared to Nandi County, farmers are more prone to looking at dairy as business; younger entrants in particular lead *technical upgrading*. Farmers invest in dairy or specialize in heifer breeding, bull fattening, or hay production. Yet a considerable proportion of farmers hesitate to invest in more intensive dairy production. The required investments in a zero-grazing unit (barn), forage storage, forage planting and preservation are seen as risky, due to high interest rates and uncertainties in the milk market (insufficient collection guarantees; fluctuating prices; and high retail price over farm-gate price ratios, up to a factor 3). *Value chain upgrading* is characterized by significant competition between around eight processors and a range of milk traders, some twenty dairy farmers' cooperative societies (of which the larger have become public companies), a large number of farmer self-help groups that supply directly to processors or traders, and pooling of milk between farmer groups to benefit from volume bonuses. Traders are starting to pasteurize milk to supply milk dispensers at supermarkets and milk bars. Processors and cooperative companies such as Ol Kalou Dairy compete through supply contracts (dependability), payment conditions, and integrated services (as they do in HaHc Nandi North). On the input side, competition is evidenced by elaborate distribution networks and training outreach of a number of animal drug, semen, and feed companies (around five companies each, compared to between one and three in Nandi County) and by around 200 AI technicians, giving farmers a choice between five and fifteen technicians and over five agro-input shops. There is less choice available for animal health care and hay. Unlike in Nandi clusters, Holstein-Friesian inseminations outnumber Ayrshires by three to two, denoting larger focus on production volume to meet market demand rather than on milk composition, feed economics, and disease resistance, in the absence of incentives for higher milk solids contents. Even though a large proportion of farmers were already using AI, the county government started a subsidized AI scheme in the pre-election year 'to increase farmer access to AI and to address high AI service prices'. Private and cooperative providers regard this as undue competition. *Institutional upgrading* is more evident in the increasing emphasis on qualifications of AI and animal health technicians by County government and the Kenya Veterinary Board, to address malpractice. Road and electricity construction are ongoing but remain an issue in remote areas.

Supplementary material 3*Context Conduciveness—the Impact of Dairy Policy*

Both countries have a turbulent history of public influence on agricultural service provision, contributing to large changes in Kenya and stagnation in Ethiopia.

In Ethiopia, public actors play an overriding role in access to inputs, services, capital, and land. Major past policy changes affecting dairy farming include collectivization of land and farmer organizations under the socialist regime (1974–1991). The incumbent Ethiopian People's Revolutionary Democratic Front regime has adopted agriculture-led industrialization as the principal development strategy, which equates to economic development that builds on upgrading of agriculture. Successive Agricultural Growth Programs are gradually giving more attention to dairy. If we take feedback in FGI and VCAI as practitioner opinions about the conduciveness of public support, the picture is bleak. The regulatory gaps for private AI, animal health services, and quality assurance of feed and the low policy priority for dairy compared to crops and meat received strong negative feedback. Positive impact was reported on the improved bull distribution program by the breeding farm at Asella University, which has been active since the 1950s and has resulted in relatively high proportions of exotic blood in the LaLc Arsi dairy herd. Some positive impact was reported from knowledge shared by colleges and research stations in Asella and Bishoftu. Relatively large positive impact was attributed to development projects, both multi-lateral and non-governmental.

In Kenya, the enabling environment has varied between counties since devolution of power in 2010 [49]. Counties promote the commodities they are strong in, including dairy in Nyandarua and Nandi. This follows two decades of significant policy changes affecting dairy: very significant cuts in public services followed the Structural Adjustment Program of the IMF and World Bank (early 1990s, [48]; the resulting collapse of the dairy sector was evidenced by the bankruptcy of many cooperatives and the state processor KCC (1999); and the market liberalization policy only gradually resulted in private service delivery, with private sector priority going to post-production services. Current government equipment and capacity-building support to dairy cooperatives was welcomed by farmers but was seen as being driven by political rather than sector interests. For example, an unused cooling tank at a cooperative society in Nyandarua was seen as 'a political cooler'. In Nandi, limited provision of equipment to cooperative societies regularly seemed to be used as an excuse for poor performance.

Many interviewees complained about lack of consistency and limited geographic coverage of public services for dairy. Public agencies have a (virtual) monopoly on vaccination for notifiable diseases in Kenya and on vaccination, AI, veterinary, and extension services in Ethiopia. For example, in Kenya, routine vaccinations for notifiable diseases are often replaced by ring vaccination upon outbreak, which may be late anyway due to staff capacity issues; inadequate preventative services for vaccination and tick-control result in high prevalence of diseases such as Foot and Mouth Disease, Lumpy Skin Disease and East Coast Fever. Public and community animal health services have not kept up with the transition to improved breeds, which have higher genetic production potential but lower resistance to diseases. Ayrshires are perceived to be more disease-tolerant than Holstein-Friesians but still need good preventative measures. Withdrawal of dairy extension services in the 1990s resulted in declining farmer skills and ultimately in declining yields. Small milk sales volumes allow for purchase of very few external services. Farmers in Nyandarua acknowledge that the county government recognizes problems in dairy support services, but they see it as choosing the wrong instruments to address them, such as public investment in processing plants and subsidized public AI services.

In both countries, governments use subsidies to promote uptake of more market-oriented practices and to make services more accessible to farmers in remote locations and with fewer resources. However, eligibility conditions and implementation flaws can have adverse effects. In Kenya, interviewees mentioned many downsides to the county government subsidizing inputs such as fertilizer distribution, cooling equipment, and the AI system. Though relatively well designed in



terms of accountability and pricing, the latter is still vulnerable to political whim (i.e. risk of discontinuation). In Ethiopia, public monopolies on most inputs and services lead to insensitivity to demand, a focus on select clients and lack of a level playing field for private providers. In principle, public services should be open to all farmers who meet the criteria, but in practice, the focus may be on farmers who are easy to reach (geographically or socially). A supply- driven rather than demand-driven system results in competition with private providers for accessible clients, while the more remote farmers may not receive services from either type. The net result may be unfair competition for private providers as well as low coverage and low service quality levels for farmers. In both countries, subsidies seem to have also created dependency on chemical fertilizers, with manure becoming relatively expensive. This has led to soil fertility issues, such as leaching and acidification. The injudicious use of agro-chemicals is affecting human health, water quality, and product quality.

The clusters studied are not prone to natural disasters, but they are subject to marked seasonality of production and the occasional drought. Farmers do worry about more erratic weather, but they worry more about the threat of disease, to which exotic breeds and crossbreeds are more susceptible.

In summary, dairy farming development in Kenya was punctuated by market liberalization policies connected to the Structural Adjustment Program in the early 1990s. Major cuts in public service supply initiated a collapse of the (processed milk) sector, which has taken a significant part of the past 25 years to recover. In contrast, the Ethiopian dairy sector saw no such disruption, but low consumer demand and lack of conducive policies have not led to a flourishing sector. Despite many development interventions supporting a formal sector, the market share of pasteurized and packaged products has not yet exceeded 2% [50].