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High quality, high reliability: The dynamics of camel milk marketing in northern Kenya

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Abstract

In order to analyse the transformations faced by pastoralists in coping with the uncertainties of their livelihoods, this paper analyses the evolutions of the marketing of camel milk, which has turned from a local taboo into a critical asset for the pastoral communities of Isiolo, a county typically associated with the rearing of cattle. Camel milk marketing (CMM) challenges several assumptions about pastoral societies and their supposed embedding conservativeness, inefficiency and risk aversion.

A high-reliability perspective has been instrumental in revealing the ongoing dynamics that are reconfiguring pastoral resource management and livelihood patterns in Isiolo. Through this approach, the management practices and contractual relationships that underpin CMM production and marketing have been explored, with a view to unveiling the rationale inspiring the networks through which camel milk is transacted, and the related socially-regulated arrangements and practices. The social and political embeddedness of CMM networks is central to their ability to adapt and function in constantly changing local conditions.

The marketing of camel milk provides an intriguing insight into how pastoral systems are informed by a high-reliability approach to operating under conditions of volatility and uncertainty. Political economy matters will have a significant influence on the evolution of this important enterprise. Adequate investments in infrastructure and public facilities would be crucial to further develop CMM and to enable its operators to respond and adapt to local dynamics, with a view to fairly share the associated risks, costs and benefits.

Keywords Drylands, Pastoral markets, Camel milk, Networks, Kenya, Horn of Africa

Camel milk marketing: A reliable economic rationale

Camel rearing and the marketing of its products constitute a significant and evolving asset for pastoral economies around the world. From the Sahel to South-East Asia, the importance of camel for dairy production is growing, triggered by socio-economic as well as agro-ecological dynamics (Köhler-Rollefson and Rathore 2009; Faye and Konuspayeva 2012; Faye et al. 2012). The marketing of camel milk (CMM) has become a particularly significant enterprise for the populations inhabiting the Horn of Africa drylands. This phenomenon has transformed northern Kenya into a major regional hub for camel milk (CM), following on and developing from similar processes and trends in neighbouring countries, Somalia and Ethiopia (Nori et al. 2006; Sadler et al. 2009; Seifu 2011; Abdullahi et al. 2013; Sisay et al. 2015; Galma 2015). The case of Isiolo county, located about 300 km north of Nairobi and characterised by unpredictable and erratic rainfall patterns, is discussed here.

This work aims at complementing existing studies and analyses on the commercialisation of pastoral products, which typically undertake a value chain perspective, where progress is linear and the modernising direction set. Accordingly, CMM is confronted with the challenges of the formal and institutionalised aspects of production

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optimisation, economic returns and marketing practices (Musinga et al. 2008; USAid 2013; Mwaura et al. 2015). Here the focus is instead on the operational principles and the contractual arrangements that link and bind the different agents along existing CMM networks in Isiolo, and that informs its adaptive and resilient abilities (Anderson et al. 2012; Elhadi et al. 2015).

A high-reliability perspective was chosen for the analysis. To operate successfully in the highly unpredictable conditions that characterise drylands, pastoralists aim to generate stable and reliable output supply from a continuously variable set of inputs, be they rainfall, market price, security or access to grazing (Roe et al. 1998; Krätli and Schareika 2010). This approach looks at the ways pastoralists articulate livestock, labour and land resources to provide for fairly constant livelihood levels out of volatile and variable conditions, as exemplified in Fig. 1, with reference to the seasonal supply of household milk in Isiolo (Roe 2020; Nori 2021).

The analysis of CMM evolutions in Isiolo in the last two decades has been undertaken through field visits and semi-structured interviewing with the involved agents at diverse levels (i.e. camel owners, herders, transporters, collectors, sellers), as well as with other local key informants. Fieldwork has been complemented with an analysis of the database of milk transactions of Anolei and Walqabana cooperatives during the last decade, and a review of the reports by their supporting agencies. Survey materials have been organised with a view to infer how reliability is generated and managed in milk transactions and how the risks, responsibilities and benefits are shared along the CMM networks.

The paper starts by exploring the features characterising camels, their milk and its marketing, as part of a wider, more comprehensive encroachment of the camel system in the Horn drylands. Milk marketing in northern Kenya is then assessed; the Isiolo system is compared to that located in Laikipia, with a view to unveil how these differ in terms of efficiency, reliability and inclusivity. By examining how camel milk networks interface with the more formal institutional set-up, potential implications of CMM evolutions are discussed and recommendations provided accordingly.

Northern Kenya drylands

Over the decades, Kenya has become one of the major producers of camel milk in the world; the implications for local economies and communities in dryland settings are significant, in terms of income, employment and social support systems (Musinga et al. 2008; Iruata et al. 2015). The thousands of litres of camel milk that Nairobi receives daily from northern Kenya are mostly channelled through two main, different systems underpinned by quite diverse assets and networks, which also result in different products targeting specific constituencies. A more formal system supplies shops and supermarkets with the milk produced in Laikipia ranches and pasteurised in Nanyuki. Another system supplies milk produced by camels roaming the northern rangelands to the Eastleigh district in Nairobi, inhabited largely by Somalis, who demand raw milk as they believe its properties would be otherwise lost through pasteurisation (Dokata 2014). This latter system has boomed in recent years, converting Isiolo county, traditionally associated to the rearing of Boran cattle, into the major provider of camel milk, supplying an estimated 75% of the overall amount marketed in Nairobi (Musinga et al. 2008). The thriving CM trade provides direct benefits to more than 10,000 people in the county, representing a strategic livelihood asset and source of employment also for the most vulnerable population groups (Anderson et al. 2012; Elhadi et al. 2015).

Much like most drylands in northern Kenya, Isiolo, has undergone intense changes in recent decades, with significant implications for the wider agrarian economy. While climatic data do not seem to highlight any dramatic shift in rainfall patterns (Pricope et al. 2013), significant changes in vegetational cover and land use might be attributed to the overall increasing pressure on natural resources. An important contributor to environmental changes in the county is demography, in human and livestock terms. Human population has increased about tenfold in five decades—from an estimated 30,195 in 1969 to 268,002 in 2019 (KNBS). This is the result of local fertility rates and falling mortality, as well as the influx of people and communities from neighbouring regions, including Somalis who migrated to northern Kenya after the collapse of the Somali state in 1990 (Little 2003). Typically described as the home of the Waso Borana, Isiolo is today inhabited by a diverse and composite human community. The relationships and dynamics amongst the different groups are an important source of local uncertainties. The geographical shape of the county is itself the probable outcome of power relationships amongst the different communities, and a significant trigger for controversies and conflict (Saafo and Kaarhus 2011). In pastoral terms, the county has three main areas which differently connect to milk marketing: the central portion surrounding Isiolo, the Kulamawe corridor and the eastern clusters (refer to Figs. 2 and 3).

Infrastructure development and basic facilities remain scanty in Isiolo, which still ranks amongst the country's poorest areas. A significant part of primary services and technical support in the area depend on international organisations, including for water supply and for the provision of livestock health. The county has

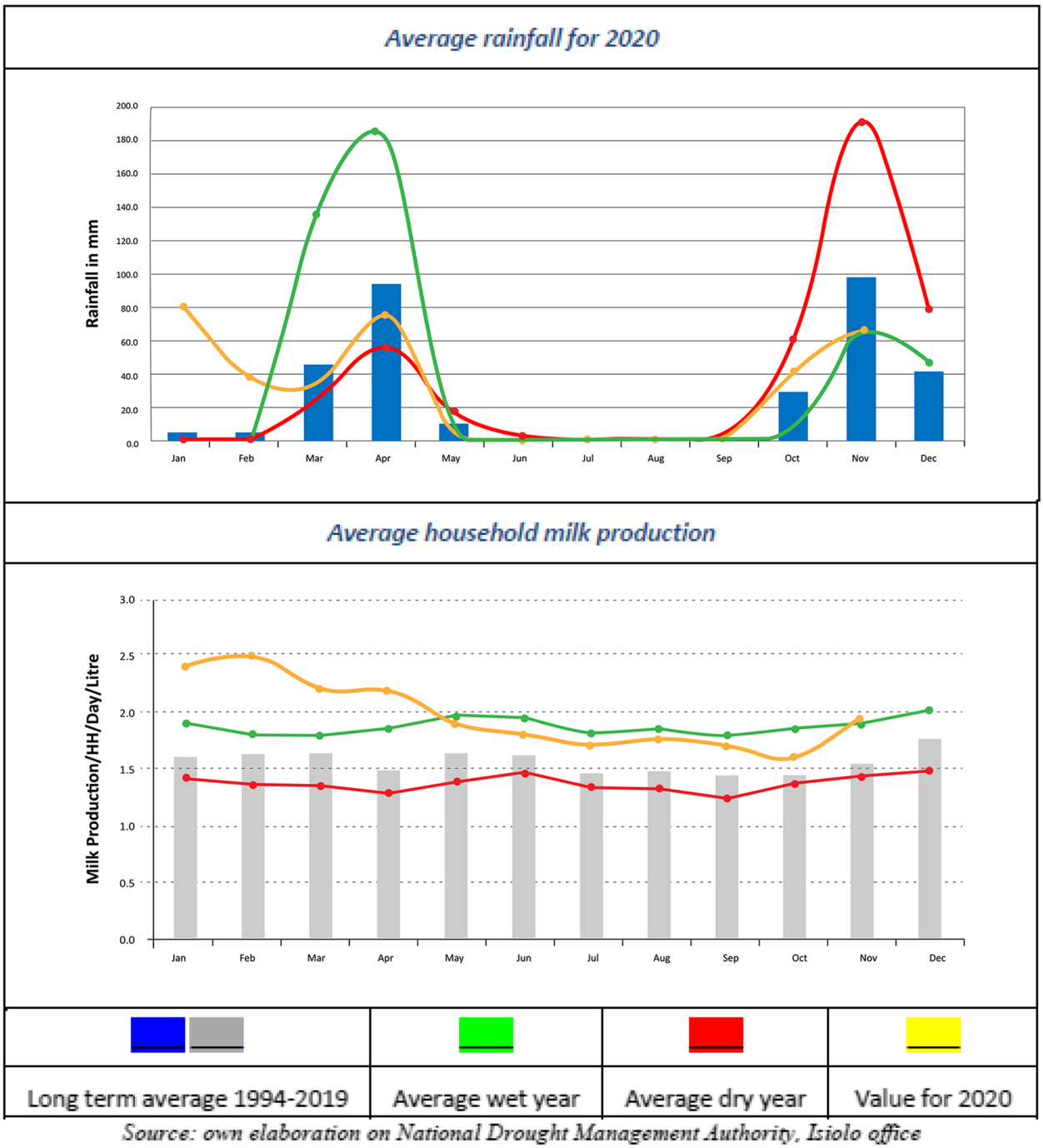

Fig. 1 Seasonal supply of household milk in Isiolo. 2020 against 1994–2019 average (Mohamed 2022 based on NDMA data)

recently undergone important infrastructure investments, related to the LAPSSET (Lamu Port-South Sudan-Ethiopia Transport) initiative, through the expansion of the electricity grid and all-weather tarmac road with the aim to convert Isiolo in a hub connecting inner Sudan to the Kenyan coast. In this framework, significant levels of public and private funding are taking place amidst other forms of policy processes and external interventions, ranging from the devolution inscribed in the 2010 Kenyan Constitution, to development assistance and conservancy programs, which further contribute to remoulding the socio-political landscapes that underpin the drylands economy. These dynamics push pastoralists to the periphery displacing them from the primary lands,

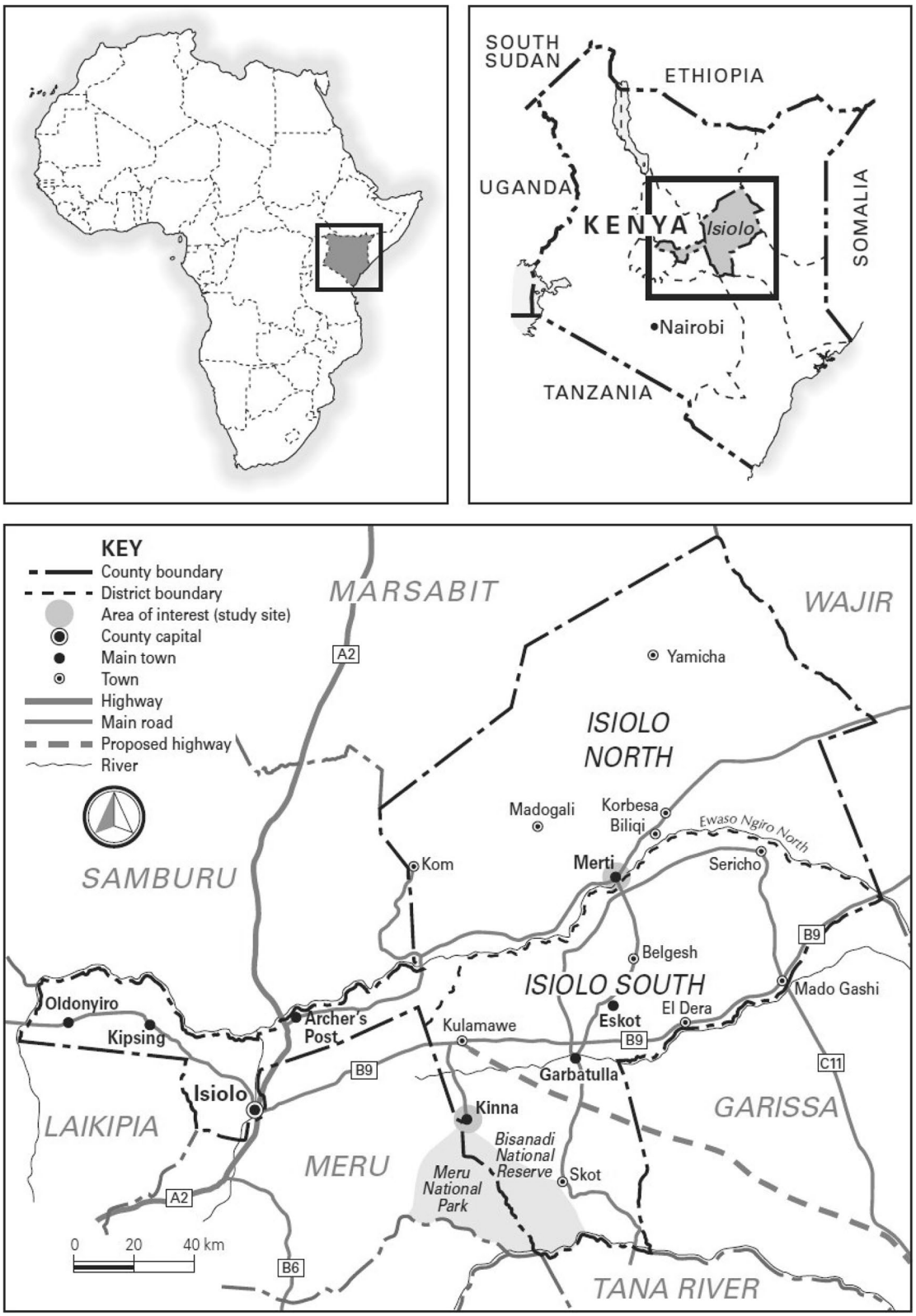

Fig. 2 Location of Isiolo county

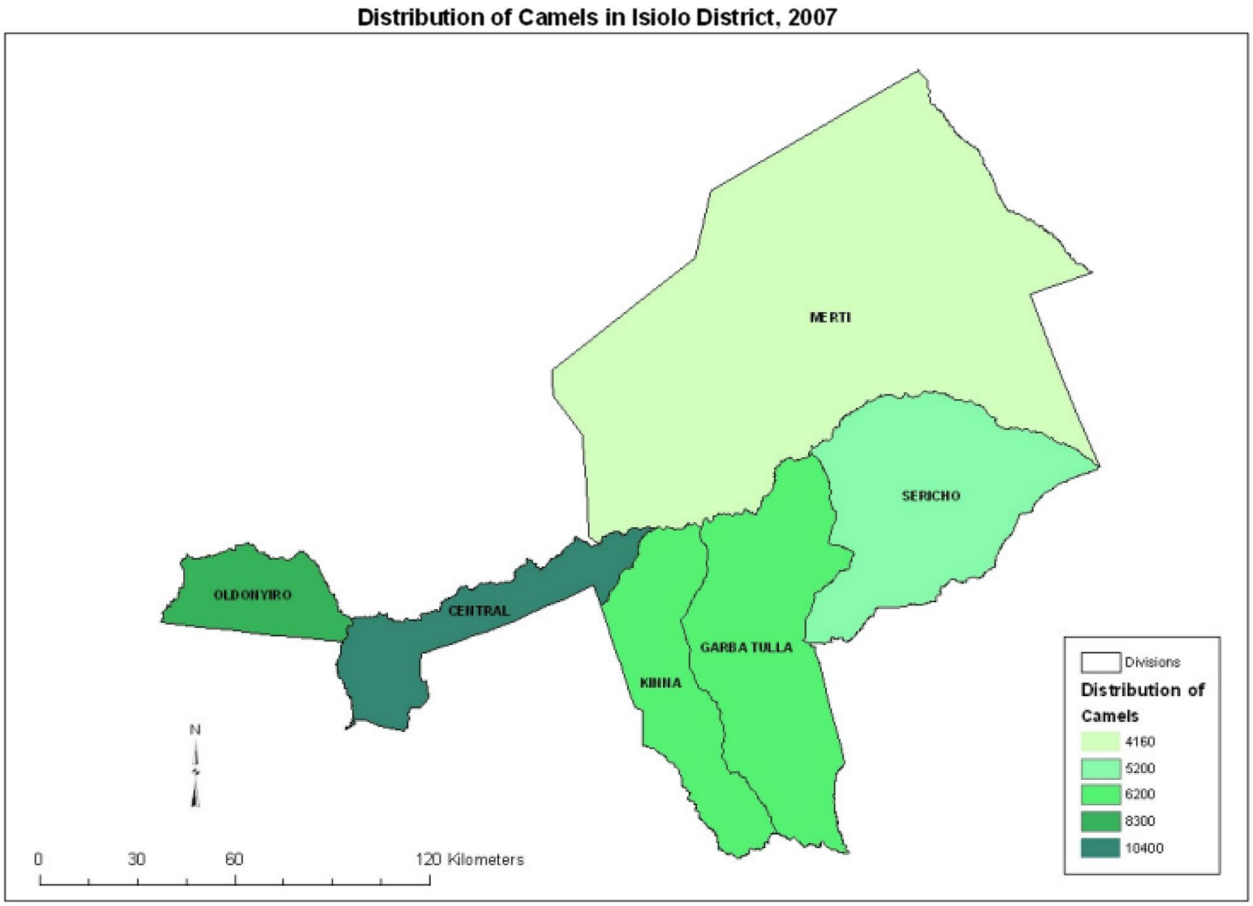

Fig. 3 Camel milk production areas in Isiolo (Musinga et al. 2008)

but locate them as well at the centre of new interests and networks. Overall these provide local communities with new uncertainties, in terms of risks and opportunities to sustain their resource management, governance mechanisms and livelihood strategies (Nori 2019; Lind et al. 2020; Mohamed 2022).

As part of a wider regional sub-Saharan African pattern, significant portions of formerly mobile pastoral populations have settled near urban towns, also in response to drought-induced livestock losses, increased involvement in market economies and inter-ethnic tensions (Noor et al. 2013; Catley et al. 2013). While livestock figures in pastoral areas are seldom reliable, there is little doubt that in recent decades livestock population has significantly increased and changed in relative proportions (Table 1). As for cattle, the increase in numbers has been minimal, especially when compared to other species. A significant rise is evident for camels and small ruminants, and it is associated to shifting agro-ecological dynamics and an increasing commodification of pastoral products (Kagunyu and Wanjohi 2014; Mwaura et al. 2015; Watson et al. 2016; Mohamed 2022). The increase in donkeys shows the growing relevance of mobility and transportation in the area. It is likely that the general increase in pressure on natural resources has been accompanied by a decrease in the average herd size per household.

Kenya has the fifth largest camel herd in the world, estimated at a few million. Although the figures change drastically depending on the source, they all attest to the fact that the trend is increasing dramatically. A largest part of camel inhabits Kenyan northern drylands, as they are traditionally kept by Somali, Rendille, Gabra, Garre and Turkana communities; but more recently

Table 1 Livestock population in Isiolo county 1979 to 2019 (KNBS 2019)

District/Sub	Cattle	Sheep	Goats	Camels	Donkeys
Isiolo total in 1979	201,900	210,000	192,000	25,000	3,200
Isiolo total in 2019	271,589	854,725	1,030,005	148,859	33,692

also Borana, as well as Samburu, Pokot and Maasai have turned to including camels in their herds, particularly since early 2000s (Noor et al. 2013; Kagunyu and Wanjohi 2014). This phenomenon is reported more broadly across the sub-Saharan African drylands belt (Jones and Thorton 2008; Faye et al. 2012). Rearing camels reflects a sophisticated resource-use system that uses mobility, social cooperation and intensive labour inputs (Watson et al. 2016). While camel keeping is widespread throughout the county of Isiolo, it follows social cleavages, and differentiations exist in camel breed, herd size and management patterns. 'Rearing camels can be very relaxing; otherwise it can turn to be dramatic' (Khalif, president KCA); this would depend largely on the individual skills, as much as on the knowledge and resources available to the task, which in turn depend on local socio-politics (Schlee 1989).

Amongst the traits that make the camel increasingly appreciated are its hardiness and the ability to provide quality milk throughout the year, even in the long dry seasons (Dahl and Hjort 1976; Watson et al. 2016). In addition to the prolonged lactation, camel milk is also valued for its longer shelf life compared to that of cow and goat. Moreover, due to its purported nutraceutical properties—nutritional and health benefits—demand for fresh camel milk is high and increasing in niche urban markets. Depending on the herd nutrition, and compared to that of other animals, milk from camel might be low in cholesterol and high in certain minerals and vitamins; the high concentration of insulin provides it with specific properties (Faye et al. 2015; Abu-Rabia 2018; Konuspayeva 2020). These features have contributed to raising its demand and price during the Covid time, due to CM supposed healthy effect on diabetics (see also Nagy et al. 2021 on this matter). Whatever the evidence of its effective medical properties, quality camel milk is no doubt a precious food.

If it gets spoiled, the fermented *susaac* could still be sold at about 75% of the fresh value. For all these reasons, camel milk fetches higher prices than other animals' milk (e.g. about 20 to 50% higher than cow milk in Isiolo, according to Elhadi et al. 2015), and camels are becoming increasingly attractive also to non-traditional camel-keeping communities (Anderson et al. 2012, Unks et al. 2019). As it is consumed raw and supplied from long distances, health risks associated to CM consumption are evident (tuberculosis, brucellosis, etc.). Milk quality management throughout the network is therefore a critical operation to ensure these risks are minimised, as it will be assessed.

Demand for camel meat is also growing including for *nyiri-nyiri*, the dried and fried meat cubes traditional in the Somali cuisine. In Isiolo, several specialised butcheries for camels have been established and opportunities for camel trade and export are also increasing across the region (Mahmoud 2016). Apart from providing a source of food and income, camel plays as well an increasingly significant local role in social arrangements; camels are exchanged as a dowry and to pay fines and redeem damages and compensation of injured parties in feuds, as recently agreed in the Modogashe conflict-related agreement between Borana and Somali communities (Chopra, 2009).

Despite its critical role in ensuring livelihoods and resilience in dryland settings, camels have been traditionally poorly addressed in scientific studies and neglected by policy-makers. The interest on their management and potentials has started growing in recent times (Farah et al. 2004; Kagunyu and Wanjohi 2014; Faye et al. 2012; Nagy et al. 2022). This work aims to contributing to this raising concern. The GoK recognises that camel milk is one of the most strategic value chains in Isiolo (GoK 2014), but the institutional and legislative frames remain inadequate to harness its potentials; camel milk is not even recognised officially as a food product on its own (2014 Dairy Act not yet passed). The limitations in scientific research, formal understanding and institutional recognitions of camel production systems add further elements of uncertainty. Due to the scarcity of tailored facilities and products, pastoralists have had to adapt to camels the use of health practices and drugs conceived for other species, while technical assistance and veterinary services have reportedly decreased in the county since the end of the Arid Land programme and the process of devolution (Mohamed 2022).

Ranches, rangelands and networks

As stated, the marketing of camel milk from northern Kenya can be differentiated in two main systems. One sources milk from northern rangelands; it is centred in Isiolo and led by women and operates informally in supplying raw, smoked camel milk to mostly Somali consumers in Eastleigh. The other is based in Laikipia, managed by men and connected to large ranches, processing non-smoked milk into a pasteurised one for elite consumers. In this chapter, we introduce these two systems, informed by diverse rationales and serving different constituencies.

For the Isiolo-centred networks, main areas that supply camel milk for marketing are as follows (refer to Fig. 3): (a) the peri-urban settings in the central portion of the county, including the Isiolo holding ground and the Mlango-Ngarentare-Burat cluster, and (b) the more distant open rangelands in its eastern parts (the Kulamawe corridor that spans from Kinna to Buji) (Noor et al. 2013; Mwaura et al. 2015). The two areas enjoy different potentials and challenges in CMM terms. The first setting is

limited by the growing expansion of land privatisation schemes around Isiolo, while access to grazing areas in the eastern one is challenged by security threats. The county's further eastern clusters of Modogashe-Eldera in Sericho and Buji-Galfarsa-Malkadaka in Garbatulla are less connected to milk marketing.

Surveys in the last decade have put the total number of camels in Isiolo at around 40,000, the half of which insist in these two market-connected areas (Musinga et al. 2008; Mwaura et al. 2015). These belong to about 2000 camel owners having important socio-economic differences. The approximately 50 large owners who own 25% of the total county camel population are business people involved in different types of enterprises (many in livestock trade), often residing in Isiolo town. Rather than belonging to individuals per se, camels are typically a property of the family and often looked after by salaried herders. Smaller scale camel owners (with less than 40 camels) represent the largest part of the camel keepers (about 80% of the total) and a consistent part (about a half) of the camel population. This group is reportedly highly homogenous in their production systems and ways of operation; they often join their herds and employ a common herder to take care of them (Mohamed 2022). There are cases, especially amongst Borana pastoralists, of families that have recently acquired camels, with a view to specifically engage in CMM.

Herd management differs from a group to another, according to cultural patterns as well as socio-economic capacities (Schlee 1989; Watson et al. 2016). Lactating and non-lactating herds are typically managed separately, with the former kept close to urban settings and milk market networks (ibid.). Joint, collective herds tend to remain closer to market networks even during the dry season, while large owners might relocate their herds in better grazing areas when conditions impose, as their dependence on CMM is lower. Purely commercial camel herds also exist in the area, with wealthy traders investing in expanding their flock with the CMM revenue; these herds are kept throughout the year within easy reach of Isiolo town, with important implications for the rangeland and/or the animal health (Noor et al. 2013). In most cases, the income generated by CMM enables them to cover the costs of camel herding, including the herder salary and the rental of grazing land plots.

A large portion of herders are today salaried and often issued from neighbouring communities (Turkana and Rendille who have longer exposure to camels, but also from communities which are newer to these animals). This phenomenon is not new (Dahl and Hjort 1976; Saafoi and Kaarhus 2011), but its expansion generates new uncertainties and poses new strategic questions for camel keeping. 'Finding knowledgeable and committed herders is becoming increasingly problematic in the area' (Khalif), 'they can be arrogant, as their contractual power is high' (Genevieve, VSF-Ch). The payment includes a salary, food and often provisions for transport and communication (motor-bike and mobile phone). The evening milk might also be part of the herder's salary, which might be added to the milk marketed the next day and increase his returns.

Overall, camel management, mobility and herding patterns respond to a quite fluid rationale, whereby resources are continuously reallocated according to prevailing conditions, mostly hinging of grazing availability and milk market value. 'Most camel pastoralists stress they cannot move regularly according to seasons. Each herder has to consider the particular needs of his animals, and there is little possibility for such decisions to be adequately taken by a central authority deciding for all camels within an area' (Dahl and Sandford 1978:43)

Milk produced under these systems reaches Isiolo through sophisticated supply networks supported by rural collectors and motor-bike transporters (*boda boda*). These community networks exist and operate in a variety of forms and patterns, and they reconfigure as conditions vary. At the heart of the networks, there are few companies based in Isiolo town, managed by women and characterised by different ethnic configurations, market management and institutional arrangements. A significant number of the women members of the CMM companies are members of camel keeping families (Musinga et al. 2008:73; own survey).We describe now the Isiolo model through the lens of the largest CMM operating company, Anolei. It is quite popular amongst research and development agencies, and we will assess then the other existing networks based on their differences with respect to it. The Anolei cooperative started its activities in the late 1990s (few hundred litres a day) as a self-help women group of (mostly) Garre and Somali women who had recently come to reside in Isiolo (Adjuran and Degodya clans). It was formalised as a cooperative in 2010, also to facilitate access to international support and financing; counts in 2021 found about 90 members, although the figure of active operators changes from one season to another.

In production areas, the milk is collected in plastic jerrycans which are smoked with charcoal from specific plants[1] to help maintain milk freshness. According to local understanding, smoking disinfects the containers, reducing the numbers of microorganisms and thereby extending milk shelf-life, and conferring a special taste

[1] *Olea africana*, *Acacia nilotica*, *Balanites aegyptiaca* and *Combretum* spp. (Wayua *et al.*, 2012)

and flavour to it. Pastoralists believe that if not properly fumigated, milk would spoil regardless of hygiene measures taken (Wayua et al. 2012:5; Wanjala et al. 2016); there are scientific studies attesting to the effectiveness of this practice (Ashenafi 1996). Milk is then cooled prior to be transported to the central Anolei cold storage plant located in Isiolo town. Before acquiring its own plant, Anolei members had organised a network of cooling hubs in Isiolo town made up of several freezers, with an overall capacity of hundreds litres, which enabled them to maintain the milk fresh for the night. The freezers were eventually also hired out to non-members (Musinga et al. 2008:46).

At the plant, the milk undergoes quality scrutiny by a dairy technician to check for acidity, water content and microbial presence through alcohol test and lactometer. It then is semi-pasteurised and chilled again and stays overnight in the cold storage. The following morning, the milk is retransferred from the cooling tank into cleaned plastic containers and sent to Nairobi with the Anolei truck. A sophisticated system of Jerrycan labelling enables their allocation to the respective retailers and clients in the Eastleigh district. The milk is commercialised in 5/7000 lt daily as fresh, raw and with a smoky flavour, in order to serve the specific demand of the local Somali community.

Main reasons Anolei women enjoy CMM include having a stable source of employment and income that allow satisfying household needs, including paying bills and fees. Household activities related to CMM are therefore critical in ensuring their existence in the urban economic setting. When explaining the rationale behind their membership to the cooperative, most women mention the pooling of resources and the collective action which have been instrumental to largely improve milk storage and management. Joining forces has also enabled attracting external support towards significant technological improvements (Table 2).

Eastleigh hosts more than a hundred CMM agents who receive several thousand litres of raw milk per day (up to 20,000 daily in 2008), mostly from Isiolo but also from Garissa and Kajiado (Musinga et al. 2008:81). Out of the total milk received, about a half is sold directly wholesale at 25% discount price to restaurants, hotels and bars within Eastleigh, as well as to some households who have freezers and are able to take volumes of 5 l or more to store, and eventually marketing it through door-to-door, including hawking in other neighbouring estates. The remaining half is sold at wholesale price to retailers or even in open air directly to consumers, where retail margins are higher. CM can also be part of a wider commercial activity that might also include the sale of other staples, including *nyiri-nyiri* camel meat. The price of the CM per litre changes little throughout the year, apart from situations of drought and scarcity, while quantities and quality do change with significant implications for the relative risks and returns for the different agents.

Overall, Anolei receives milk directly from producers, transporters, traders and rural collectors. Apart from its own supply systems, Anolei also purchases and sells milk from other groups and individuals. Their overall financial turnover has been quite impressive. When needed and the price allows, milk can be supplied from as far as Maralal (Samburu) and Moyale (Marsabit) through the use of public buses. Due to their long-standing presence, their extended networks and the huge volumes traded, Anolei holds a dominant position in the Isiolo CMM, and their managers define the price, set the rules and provide sanctions to enforce them (such as fines, suspension and/or expulsion from the trade), providing a form of monopoly to the Isiolo CMM system (Muloi et al. 2018).

Not all suppliers though enjoy the same rights and benefits. It could be said that Anolei operates through two main sets of suppliers:

Table 2 Technical evolutions of the Isiolo CMM networks

Milk transport				
From	Donkeys and bikes		Public buses	
To include		Boda-boda motor-bikes		Refrigerated trucks
Milk control and processing				
From	Charcoal smoking		Control system at cooling site	
To include		Network of freezers		Centralised control and cooling system
Money transactions				
From	Bartering		Daily cash on the spot (in the jerrycan)	
To		Use of bank accounts		M-Pesa on bi/weekly basis

a) Primary suppliers, core group and also members of the cooperative,
b) Secondary suppliers, a contingency group of producers and collectors who at times supply their milk to Anolei, especially in times of scarcity (i.e. dry seasons).

The main difference is that during the wet season, when CM supply is in excess, Anolei gives preference to its core group/members, and then from secondary suppliers: 'when it is dry they come to seek us, when we have plenty in the rainy seasons they refuse to take our milk' (Hamida). Payments from wholesalers and to suppliers are made every 2 weeks, through direct cash, M-Pesa or even in-kind to rural producers (sugar, grain and other household items associated to the jerrycans coming back from the markets). Payment modalities and overall economic benefits differ as well for non-members, who claim enjoying a limited say in the CM price definition, and differential treatment in payment.

Together with Anolei, other self-help/cooperative women groups operate much along the same lines. They, though, originate from and operate through other clans or communities and diverge in some ways from Anolei in terms of operations and products. Tawaqal members mostly belong to Somali Issah and Harti clans, who have long resided in Isiolo. It diversifies its processing with flavoured yoghurt and its commercial activities with *nyiri-nyiri*. To carry products to Eastleigh, Tawaqal uses public transportation or contracted lorry, instead of its own means. Walqabana involves mostly Borana women who reside in milk production areas, where they collect milk and send it to Isiolo to be sold to other companies for onward processing and marketing. Both Tawaqal and Walqabana receive support from international organisations to further develop their processing and storage capacities. Similar to Walqabana is the case of another women cooperative, Galesa, a group of Borana women who own camels themselves as they have benefitted from a camel restocking programme from an international NGO (VSF).

In these cooperatives, members pay a fee to the cooperative for cooling and transport services, but effectively manage their milk quantities on their own in terms of supply as well as of marketing. Non-members can make use of the services, but at a higher price. In most companies, part of the funding is allocated by way of mutual assistance, including informal saving and social support schemes. In spite of a long-standing exchange of milk and money on a daily basis, and sharing significant risks in terms of milk quality and money transactions, a large portion of these women barely know each other or have physically met. They often got connected through a common friend/relative, who played somehow as a guarantor in what are defined as *business-relations* during the interviews. This means that trust is generated through the reliability of their interactions and the fairness of these exchanges, mostly assessed in milk quality and money timing terms. If someone fails, he/she is out of the system. The traceability in the system is though so intense that in case needed, one operator could easily track the other. This makes these relational chains indeed business-related, but also heavily socially embedded.

Fresh raw milk flows though these networks thanks to a transportation system centred on motor-bikers (boda-boda drivers (BB) who provide transport services to the women's companies, but maintain as well degrees of autonomy in directly engaging with producers. Boda-boda are critical links between production, collection and trading nodes of the CMM network. They have replaced donkeys and bicycles, as roads have improved and motor-bikes are more easily available. BB relocate seasonally, shifting from an area to another according to conditions, following boma camps and continuously connecting production and collection areas. They can carry on each trip up to 2/300 l and their moves are dictated by distances, number of clients, road conditions, milk quantities and timing. These factors change across seasons, and so do the real costs and potential returns. BB transporters in Isiolo can be divided in two different groups: (a) rural—those riding on mostly dirt roads and supplying milk from hinterland grazing areas to milk collectors, and (b) tarmac—those that ride on the tarmac road connecting Isiolo to the collection areas.

BB transporters may perform their own entrepreneurial activity on top of providing the CM transport service to the women companies. For example, some combine transport and trade and exercise their own enterprise by purchasing and reselling milk on their own. A progressive career into boda-boda might imply starting as a herder, then becoming a hired driver of before purchasing a motor-bike (out of CMM money) and establishing a milk business on its own. Every morning a CMM boda-boda transporter faces different potential scenarios, depending on the cooperatives' arrangements, the milk production levels and market price, and the distance of production areas. He might stick to the cooperative requirements or negotiate with other producers, collectors and transporters to adjust its transport capacities to existing circumstances and potential opportunities. Decision-making takes place daily through some phone calls and meetings along the road and at collection points. This real-time decision-making process makes boda-boda transporters high-reliability professionals (more below), able to modulate supply according to shifting conditions. Figure 4 sketches the features of the different Isiolo CMM networks and flows.

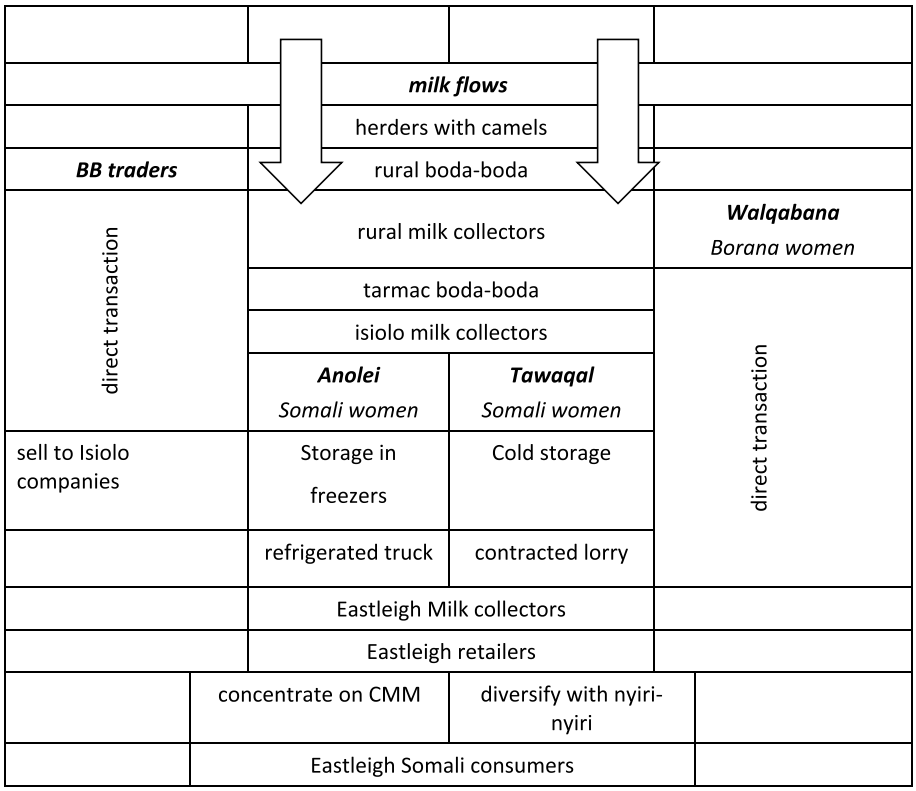

Fig. 4 Community-based CMM networks operating in Isiolo county

Furthermore, there is another more formal system established in Laikipia county that enjoys wetter agro-ecological conditions, with basically two men-manned companies in Nanyuki, White Gold and Northern Goodness, having limited operational capacities (few hundreds of litres daily). These are the spin off from the previous Vital company that started the CMM business in the early 2000, with the assistance of international agencies (Field 2006). These enterprises collect milk directly from the large ranches in Laikipia, which started raising camels in the 1970s. There are about 15 such ranches, with an average of 200 camels each, that make quite intense use of veterinary care and management practices. Milk is directly marketed from the ranch to the company, with no intermediaries (Musinga et al. 2008; Noor et al. 2013).

Milk arrives at the plants in Nanyuki fresh and non-smoked; it is checked for quality and then it is pasteurised, cooled and packaged for the formal market. It travels in refrigerated trucks and if the cold chain is maintained, its shelf-life lasts about 3 weeks. This non-smoked and pasteurised CM is commercialised in shops and supermarkets in Nanyuki and Nairobi at about double the price of the women-led systems. This milk is controlled and processed through sophisticated technologies and serves the demand of an affluent clientele that is mostly interested in the supposed nutraceutical properties associated to camel milk. It might comply with a certain degree of quality and hygiene standards, when existing for national or export markets.

Similar to the Laikipia model, other such companies centre around significant capital investments established and managed by men. These companies receive important external support but operate at a reduced scale and provide altogether for less than 5% of the camel milk available in Nairobi (Muloi et al. 2018). Despite their export potential, a main shortcoming for these formal companies is their incapacity to engage with the Isiolo networks. There are technical issues, such as the milk supply quantity and continuity, and problems related to milk quality standards, including hygiene and the smoked taste. But there are as well socio-political aspects, as CMM women prefer serving their producing and consuming constituencies and maintain their degree of autonomy and control of the CMM. 'They want to retain their control and flexibility of the system' (Jilo, local researcher). Experiences indeed show that evolutions of the dairy sector towards more 'modern', standardised and regulated practices oftentimes prove little favourable to local agents, from producers to collectors (Field 2006; Anderson et al. 2012).

Able, liable and reliable: CMM agents, roles and rules

The extended and articulated networks that connect production, processing and consumption areas and agents are critical in enabling camel milk marketing to take place amongst significant uncertainties, challenges and opportunities. These networks are organised as reticula, grids of nodes that link different but functionally interconnected landscape units with specific production or marketing potentials (Nori 2019). Overall, this pattern accompanies the spectacular rate of sedentarisation of pastoral populations and enables a structural continuity between rangelands, urban settings and the wider national and regional arena. Such processes are critical in integrating and supporting dryland economies throughout sub-Saharan Africa (Catley et al. 2013; Mohamed 2022).

The articulation of milk networks in territorial grids is enabled by technical arrangements and governed by a tailored set of institutionalised rules and regulations. On the one hand, CMM is underpinned by physical infrastructure and facilities, such as road networks, motorbikes, smoked jerrycans, mobile phones, cooling systems and storages and M-Pesa financial services. On the other hand, its operations and performance are embedded in a sophisticated institutional setting that leans on ethnic affiliation, moral economy, social networks and their interconnectivities. The social embeddedness of such bonds and the repeated interactions are critical in establishing and sustaining trust, generating reputation and enabling transactions amongst agents, whose relations are by and large, as we have seen, business-centred involving persons who barely know each other personally. Much like herders enforce territorial control through their regular presence, the continuous and reiterated exchanges amongst the different agents and networks are critical in reinforcing the relationships that enable CMM transactions, supported by information and money flows facilitated by M-Pesa and phone networks.

The different CMM agents display skills and core competencies in responding to specific tasks and responsibilities through socially regulated practices and capabilities that continuously remodulate according to prevailing inputs and conditions (i.e. what Roe defines as *special institutional knowledge*; 2020:10). On the one hand, rural agents must ensure that milk supply and features be preserved across seasons; on the other hand, urban-based agents must comply with timely and fair payments and the associated services. In order for the CMM networks to ensure high reliability, three critical, interconnected domains have to be accounted for: seasonality in milk production, milk quality and related conditions, and milk pricing and payments.

Seasonality is a key aspect of camel milk production and therefore carries pertinent implications for its marketing, in terms of logistics as well as for milk quantity, quality and overall value. CM quantities, when commercialised, change through seasons (from 30 to 50% more during wet seasons, as a tentative average), while the price in terminal markets changes limitedly. However, what does change across seasons are the uncertainties, costs and returns for the different agents: some benefit more during dry seasons, while others' interests better prevail in the wet ones. Pastoralists get paid about a third more during the dry season, and the service fee of the different agents across the network also varies.

In order to accommodate seasonal variations to a fairly stable milk flow, CMM networks display important degrees of flexibility in the relationships amongst the different agents. Much like camel owners keep animals in different herds and locations, so most CMM agents transact with more than one agent along the network; each urban collector in Isiolo is connected with an average of 3 to 5 collectors in the rural areas. The same applies for Eastleigh sellers who are connected with several Isiolo collectors and with several retailers locally. BB transporters as well can link with and serve producers and collectors in different areas and seasons and add or drop suppliers in real time, according to the information received from the production and marketing environments.

Likewise, *milk conditions*, including but not limited to its quality, are as well a most critical factor in the network operations, deserving an intense system of monitoring and feedback. As CM is in fact consumed mostly raw, its quality, pureness and freshness are instrumental to its marketing. The health risks and social dread associated with its contamination provide further incentives to an effective quality control system. Accordingly, milk features are checked at the different steps through its look, smell and taste, with a view to manage whether it is fresh, uncontaminated and whether the process of fermentation has begun. Anolei and Tawaqal companies have invested in facilities enabling more technological-supported quality analysis before milk from different sources gets mixed into the cooling system.

Throughout the networks, significant incentives are applied to ensure milk quality and conditions are reliably cared for. Jerrycans are cleaned and smoked by rural agents (who are thus held responsible), bad-quality milk is returned to the producer/collectors and poor milk conditions are a major criterion for being dropped from the system. It appears that the system of sanctions is effective in ensuring basic standards before passing milk to the next step; though simple the implemented measures and

control systems may be, milk contamination or spoiling is little reported throughout the chain, and milk conditions in terminal markets do not seem to be a major matter of concern, as reported by agents at the various CMM steps, as well as by the reports of supporting institutions (SNV, VSF). Moreover, in case needed, the network functioning provides traceability of milk to a good degree. Milk safety remains though a main concern for public authorities (GoK 2014).

The arrangements behind *milk price distribution and its payment* represent the third pillar of the networks effectiveness. The flow of market information and money are critical in informing and maintaining the management of the networks. The price of the milk has to accommodate several factors, including quantity, distances, transport and market access. While the final market price changes narrowly, strategic negotiations and decision-taking take place on its components and their (re)distribution across the network. Almost all CMM agents report continuously experiencing problems in their operations (Dokata 2014). Despite seasonal variations and varying economic conditions, agents engage nevertheless in CMM throughout the year so that the system keeps operating, relationships remain active, participation is guaranteed, and real-time fallback options in case of unforeseen events remain in place.

Apart from generating cash income, most agents participate in CMM for several collateral benefits, which are critical in enhancing pastoralists' resilience in a context of increasing uncertainties. CMM has become a critical service for the whole dryland community to support connectedness, exchanges and forms of social support which are today a vital part of local livelihoods. The sale of camel milk is not only a way of disposing of milk surpluses during the wet season, but also an integral part of the pastoral household economy to generate the income necessary for purchasing other essential food items, especially during the dry season (Mwaura et al. 2015).

The adaptive flexibility that characterises milk networks is the result of the intertwining of the individual and collective dimensions of its agents. Despite its social embeddedness and bonding, CMM networks leave in fact room for manoeuvre to its different agents, who enjoy significant degrees of autonomy towards a continuous, real-time modulation to prevailing conditions (Roe 2020). Such socially regulated arrangements are critical in sustaining the network reliability, whereby business is individual but uncertainties are dealt with collectively and interconnectedly.

Weaving networks

As drylands are characterised by ecosystem as well as institutional dynamics dictated by highly unpredictable conditions, local communities engage in actively managing input variabilities to achieve sustained livelihoods in new ways. In this perspective, CMM networks are conceived as complex socio-technical systems interconnected and operating according to specific reliability mandates, that is, to ensure a low and stable output variance (reliable quality milk supply) out of an increasingly volatile input supply (i.e. access to water, land, livestock, labour, etc.). Proactive risk management is in fact *the* option when you do not have entire control of the system at any one time (Roe 2020:18).

Without such a framework in mind, it would be difficult to understand and appreciate the vibrant transactions and transitions taking place in northern Kenya. The main difference between the Isiolo networks and the Laikipia systems resides in the respective rationales underpinning their functioning (Table 3). While in Laikipia camel farm management aims to intensify and stabilise the input supply in order to maximise and control milk outputs, Isiolo networks instead operate with a view to maintain the system as flexible and adaptive as possible, so to respond to prevailing conditions in real time.

Marketing camel milk from drylands requires complex, intense and dynamics social networking and a high-reliability-seeking attitude, which to outsiders may look very much like risk-taking because people have no other choice but to do so. A flexible governance system is in place to inform resource management and coordinate flows of milk, information and money and to distribute roles, responsibilities and risks accordingly amongst the different agents. The social embeddedness that characterises

Table 3 Main differences between the Isiolo and Laikipia CMM channels

Laikipia CMM	*Features*	*Isiolo CMM*
Large ranches	Production areas	Open rangelands
Direct supply	Conveyor system	Networks of intermediaries
Pasteurised milk	Market product	Raw, smoked milk
Shops and supermarkets	End market	Somali Eastleigh community
Intensify and stabilise the input supply to maximise milk outputs	System rationale	High reliability aiming to a stable and reliable output supply
Commercially, men-centred	System governance	Self-help women groups

CMM networks enables their agents to operate as reliability professionals, who continuously adjust their strategies through interconnected mechanisms of collective engagement, real-time feedback and adaptive decision-making, which are critical features in the face of local (inevitably differentiated) uncertainties. Accordingly, the skills CMM agents display look little like the so-called traditional, indigenous knowledge that pertains to local pastoral societies; rather it evolves from the principles informing them, the reliability-seeking mandate that underpins pastoral resource management (Nori 2019; Roe 2020).

The transformations Isiolo drylands are undergoing reflect to a good extent the patterns seen in other pastoral regions where change is taking place at a fast and intense rate (refer to Nori 2021). Flexible herd management, livelihood diversification, reconfigured mobility, articulated social networks and reticular territorial management are the principles informing pastoral adaptive strategies with a view to enlarge their portfolio of management strategies and options to respond effectively to increasing uncertainties, as they become part of a much wider and articulated societal network (Roe 2020). The complex relations amongst the different communities inhabiting the Isiolo County go beyond the typical competition scenario and materialise as well in the form of direct relations or through market exchanges. Borana pastoralists integrate with Meru agriculture on the one hand, while relying on Somali camels and their milk market on the other; Samburu, Rendille and Turkana youth are increasingly engaged as local labour force. These arrangements are all instrumental in improving the reliability of milk production and marketing. Similarly, the ongoing negotiations with local authorities, national politicians and international organisations follow the same path opportunistically 'distancing from and integrating into', according to prevailing conditions and opportunities (van der Ploeg 2008; Scoones 2020; Nori 2021).

Sustaining reliability

Ongoing evolutions of camel milk marketing in northern Kenya attest to the responsiveness and adaptive capacities of pastoral societies, much less conservative and more proactive than they are often depicted, particularly by governments. Isiolo, a county known for Borana cattle, is today the major provider of fresh, raw camel milk to Nairobi and beyond. Not confined to particular areas and groups as in the past, camels are now central to livestock production across northern Kenya, and the marketing of their milk, once taboo, provides today an important response to the ecological and institutional transformations that are reconfiguring local drylands.

Marketing in Isiolo drylands is not just about costs, benefits, returns and so on, but about social relations, politics, identity, ethnicity, cultural connections and networks, which are as well critical in sustaining local livelihoods. The key here is the interconnectedness that comes with the pursuit of high reliability in pastoral system outputs and livelihoods. It cannot be just be a matter of efficiency, performance, quality and regulation alone, but also who gains and who is excluded, how networks generate opportunities and how flexible and reliable networks and transactions are.

The way we understand pastoral markets and their responsiveness to local uncertainties is central to how development strategies for the future are conceived. In this way, camel milk marketing presents a governance dilemma to policy-makers. On the one side, increases in the regulatory regime might contribute to improvements in milk safety, and potentially opening up more markets for milk export. On the other side, the inclusion of camel milk for marketing into conventionalised regulatory standards may endanger the capacity of the informal chains to operate. No one wants to sweep away a large part of the agents that make CMM today possible and the consumers who want raw smoked milk, together with the income- and employment-generating spin-offs.

The reconfiguration of the market and institutional domains will definitely play a significant role in the future of CMM, and in defining whether the system will evolve along privatised or collective ways, including formal or informal arrangements that seek stability or reliability, and whether it would be dominated by technologies or networks, and by men or women. Research on the impact and the trade-offs of different regulation and investment scenarios, their acceptability and efficacy in maintaining the networks' performance and in enhancing opportunities for (whose ?) development is required. The key question throughout is the effectiveness of each different arrangement in meeting the requisite variety match between task demands and resource capabilities in highly dynamic, highly uncertain dryland production and livelihood systems. To that end, the benchmark standard for comparing hypothetical alternative arrangements must remain the CMM currently evolving on the ground.

Any further thought along these lines needs though to be supported by adequate investments in infrastructure and facilities in support of local livelihoods. Recent trends have seen an important eclipsing of public services in terms of technical assistance and livestock health in the area, which importantly affect Isiolo pastoralists. The development of local infrastructure will also be key in the evolution of milk marketing; improved road networks, basic service provision, expanded phone coverage and power grids are necessary investments to enhance the capacity of milk producers and network operators to access the market and to improve the quality of their

products and services, with a view to respond to growing uncertainties and benefit from evolving opportunities.

Abbreviations

CMM	Camel milk marketing
GoK	Government of Kenya
KCA	Kenya Camel Association
KNBS	Kenya National Bureau of Statistics
LAPSSET	Lamu Port-South Sudan-Ethiopia Transport
NDMA	National Drought Management Authority
SNV	Dutch Cooperation agency
VSF	*Veterinaires sans Frontieres*

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MN carried out the field surveys and local interviews, as well as the analysis of datasets and of reference materials. The author read and approved the final manuscript.

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