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Livestock value chain transformations in Central Asia: A status from peri-urban settings in four countries

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Livestock value chain transformations in Central Asia: A status from peri-urban settings in four countries

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Cover photo Milking maid operates a milking parlour in a corporate farm in Almaty province, Kazakhstan © Martin Petrick

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ABSTRACT

This study investigates the transformation of livestock value chains in peri-urban areas of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan, focusing on the dynamics of livestock production, land use, and downstream supply chains. Drawing on unique farm-level data and qualitative research, we examine the limited progress of agri-food value chain modernisation in the region. Findings reveal that while urban demand for meat and processed food has grown, the smallholder-dominated livestock sector remains constrained by deficient fodder resources, fragmented production, and limited access to modern processing and retail channels. Despite massive growth of livestock numbers kept in rural households, livestock intensification has progressed only slowly, with large-scale enterprises representing a small but dynamic segment. Our survey data shows that smallholders rely heavily on informal market arrangements and local sales channels, often constrained by insufficient vertical coordination and limited quality enforcement. Large enterprises and feedlots often benefit from government support and exhibit advanced integration, with enhanced genetics, own processing plants, and branded retailing. This bifurcated structure in the livestock sector underscores challenges in transitioning toward modern value chains. Government interventions, including subsidies and cooperative development, have largely failed to integrate smallholders or address systemic bottlenecks. We discuss the options for inclusive strategies, such as strengthening public governance or leveraging medium-scale farmers. Our findings highlight the delayed transformation of Central Asia's livestock value chains compared to other emerging economies. We suggest that in Central Asia, intensive larger farms have some potentials to overcome many of the trade-offs inherent in the prevailing smallholder livestock systems.

KEYWORDS

Livestock value chains; Central Asia; Smallholder farming; Agri-food transformation; Peri-urban livestock systems.

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1 Introduction¹

Agricultural intensification, the commercialisation of food trade and processing as well as the emergence of supermarkets have triggered massive changes in the structure and scope of agri-food value chains worldwide. Recent literature has pointed out the impacts of this “value chain revolution” on economic development, labour conditions, and technology diffusion (Barrett et al. 2022; Reardon et al. 2009; World Bank 2020). Urbanisation plays a key role in these transformations. During economic development, incomes typically rise in cities first. Changing compositions of the workforce, wider media penetration and the globalisation of diets have driven shifts in urban food demand around the globe (De Bruin et al. 2021; Reardon and Timmer 2014).

In this process, peri-urban farming systems represent the link between spatially extended production and consumption concentrated in cities (Thünen 1826; De Bruin et al. 2021). It is also here where the most lucrative supply chains for perishable goods such as dairy or meat emerge first and come to dominate markets. Due to lower transport and logistics cost, they may outcompete more distant regions with potential comparative advantage in primary production (Barrett et al 2022, 1334).

To what extent an agri-food value chain revolution has in fact got under way in Central Asia is a largely open question. Whereas agriculture in Central Asia has been thoroughly restructured and individualised since the demise of the Soviet Union, substantial increases in agricultural labour incomes from commercialisation have yet to materialise (Petrick 2021). While agriculture is a sector considered highly relevant for rural livelihoods, economic diversification and export promotion, the region has suffered from a lack of connectivity, high transport costs, deficits in public governance and a poor business environment (Burunciuc 2019; OECD 2018). Trade statistics show that all Central Asian countries are net importers of food (FAO 2022, 6).²

At the same time, hopes were voiced that economic integration within the Eurasian Economic Union, China’s rapidly evolving engagement, and increasing investment in hard infrastructure would turn Central Asia from a “land-locked” into a “land-linked” world region (Pomfret 2016). Cities in Central Asia were expected to become hubs for agro-processing that link up with global value chains (World Bank

¹ This study draws on outputs of the project “Revitalising animal husbandry in Central Asia: A five-country analysis (ANICANET)” (www.iamo.de/anicanet), funded by the German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF), [grant number 01DK17031]. Part of the work was supported by the German Academic Exchange Service (DAAD) from funds of the Federal Ministry for Economic Cooperation (Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung, BMZ), SDGnexus Network [grant number 57526248], program “exceed – Hochschulexzellenz in der Entwicklungszusammenarbeit”, and by the Federal Ministry of Education and Research (BMBF) under the project “Economic integration of livestock husbandry in the trans-border region of Tajikistan and Uzbekistan” [grant number 01DK22003]. In addition to our funders, we would like to thank all ANICANET partners for their data collection efforts and numerous insights, especially Zhanyl Bozayeva, Nodir Djanibekov, Roman Mogilevskii, Nozilakhon Mukhamedova, Yurii Naumov, Baimat Niiazaliev, Dauren Oshakbayev, Igor Pugach, Kanat Tilekeyev, Khojamahmad Umarov and Yuliy Yusupov. Moreover, we are grateful to Jakhongir Babadjanov, Sherzod Babakholov, Tilman Brück, Gulnara Dzhunushalieva, Anton van Engelen, Irina Hopp, Adrian Neal, Torsten Swoboda and participants of the “2024 Life in Kyrgyzstan Conference” in Bishkek for constructive discussions, helpful information and assistance and Robert Blumenau for editorial support.

² In FAO (2022), Turkmenistan is a surprising exception to this statement.

2011). Income growth and the rise of an urban middle class have led to higher intakes of meat, carbohydrates and processed food, which in turn brought overweight and obesity in Central Asia to levels that are comparable to high-income countries (Akramov et al. 2024).

This article takes a first step in empirically investigating the conditions of agri-food value chains in four selected peri-urban settings of Central Asia. We focus on livestock, a key arena of value chain revolutions in other emerging economies, e.g. post-socialist Eastern Europe (Dries et al. 2009). The recent literature on agricultural value chains in Central Asia mostly concentrates on the cotton (Petrick et al. 2017; Babadjanov and Petrick 2023) and wheat sectors (Lombardozi and Djanibekov 2021). Considered strategic crops in several countries of the region, both sectors have been strongly influenced by government regulation. Livestock value chains used to be much less regulated even under socialism, and they are likely to react more immediately and thoroughly to the changing downstream conditions driven by consumption patterns and retail transformations in cities. Yet they have been little studied in Central Asia.

Utilising unique farm-level data and insights from qualitative context research on four sites in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, we explore current conditions of livestock farming systems, livestock-related land use and the anatomy of downstream supply chains. We provide detailed evidence on the state of vertical coordination, contracting and quality standards in livestock chains. Contextualising our findings and comparing them with food chain dynamics in other emerging economies yields nuanced insights into the relative efficiency of the chains, their bottlenecks and constraints, recent dynamics and potential levers for policy action.

In the following sections 2 and 3, we provide statistical background information on recent dynamics and restructuring at the retail and primary production level, the two end points of the value chain. After describing our own data collection methods, we provide an in-depth analysis of the state of livestock production and downstream activities in sections 5 and 6, focussing on small- and medium-scale livestock holdings that represent the vast majority of the national animal herds. Section 7 uses case study material to analyse vertically integrated livestock enterprises. In section 8 we start from international experience to discuss our major findings and place them in the context of debates about longer term dynamics of value chain evolution in Central Asia and the role of government policies. Section 9 concludes.

2 The context of agri-food value chain transformation in Central Asia

In a recent survey of the literature, Barrett et al. (2022, 1336-1345) described the worldwide transformation of agri-food value chains as progressing in three distinct revolutionary shifts. These involve a “supermarket revolution” transforming the retail stage, a “food service revolution” of restaurants and institutional food providers, and a “quiet revolution” of (less visible) intermediation services and processing. Common to these revolutions is the emergence of corporate, partly multinational investors in the various value chain stages, an increasing commercialisation of tasks within the stages and the logistics connecting them, the formalisation of exchange relations and contracts, and a significant technological upgrading along with the introduction of quality standards at all stages. At the primary production stage, changes have been massive in many countries and a general concern has been whether

they would drive incumbent smallholder farmers out of the market (Dries et al. 2009; Reardon and Timmer 2014).

In historical sequence, these revolutions can be described as waves reaching different groups of countries largely depending on their level of income and urbanisation. In Asia, Barrett et al. (2022, 1337) assign countries like South Korea and Taiwan to the first wave, Indonesia and Thailand to the second, and China and India to the third, i.e. early, middle and late adopters of transformations.

In order to assess the conditions for agri-food value chain transformations in Central Asia, we compare the level of urbanisation, per capita income, and the penetration of grocery retailers in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan with China and Indonesia, considered as third and second wave adopters (Figure 1). With the exception of Kazakhstan, the triangles of all Central Asian countries studied here lie within the respective triangles of China and Indonesia, implying that they are lagging behind even the third wave countries. In terms of per capita income, oil-rich Kazakhstan visibly exceeds all the other countries in the figure, but China and Indonesia still display higher or similar rates of urbanisation and grocery retail penetration than Kazakhstan. Both per capita income and retail density are much lower in Kyrgyzstan, Tajikistan and Uzbekistan. In the latter two countries, according to our data, modern grocery retail density was around one per 100 thousand inhabitants in 2021.

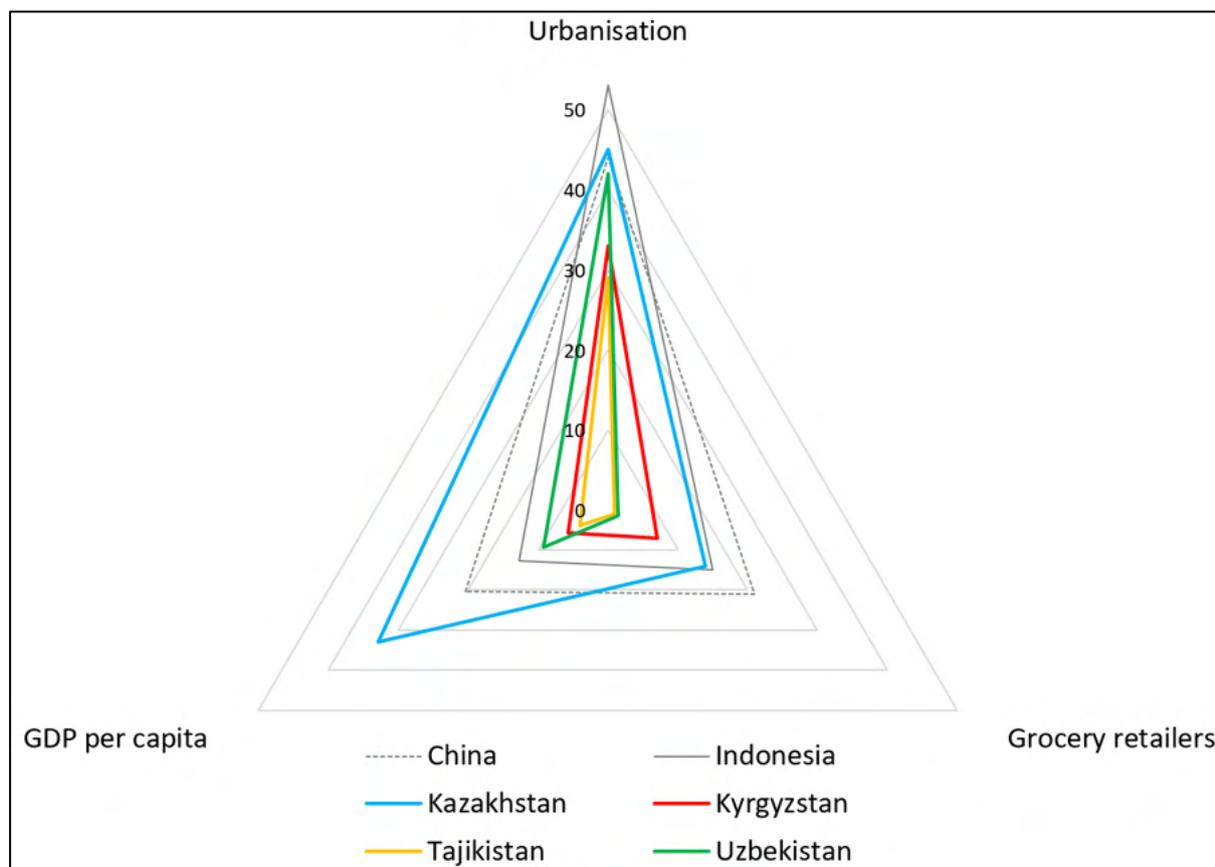


Figure 1 Indicators on agri-food value chain conditions in Asian countries, early 2020s

Source: Authors based on data from EU Copernicus (2025) for urbanisation, World Bank (2025) for GDP per capita and Global Alliance for Improved Nutrition et al. (2025) for grocery retailers.

Notes: Urbanisation is population share in urban centres in 2020 (%); GDP per capita 2021 in international PPP (1000 USD); Grocery retailers is number of modern grocery retailers per 100 thousand inhabitants in 2021.

Across all consumer goods, modern retail outlets (such as supermarkets and convenience stores) have recently gained market shares in all four Central Asian countries studied here (Figure 2). Consistent with Figure 1, the share of modern retailers is notably higher in Kazakhstan and Kyrgyzstan than in Tajikistan and Uzbekistan, reaching almost 70 percent in 2023 in the former. The remaining sales are made through street vendors, individual traders and informal sales channels. Although they gradually lost market share over the reporting period in most countries, they still play an important role as value chain intermediaries in Central Asia. In Tajikistan, their market share even increased back to two thirds of total sales in recent years.

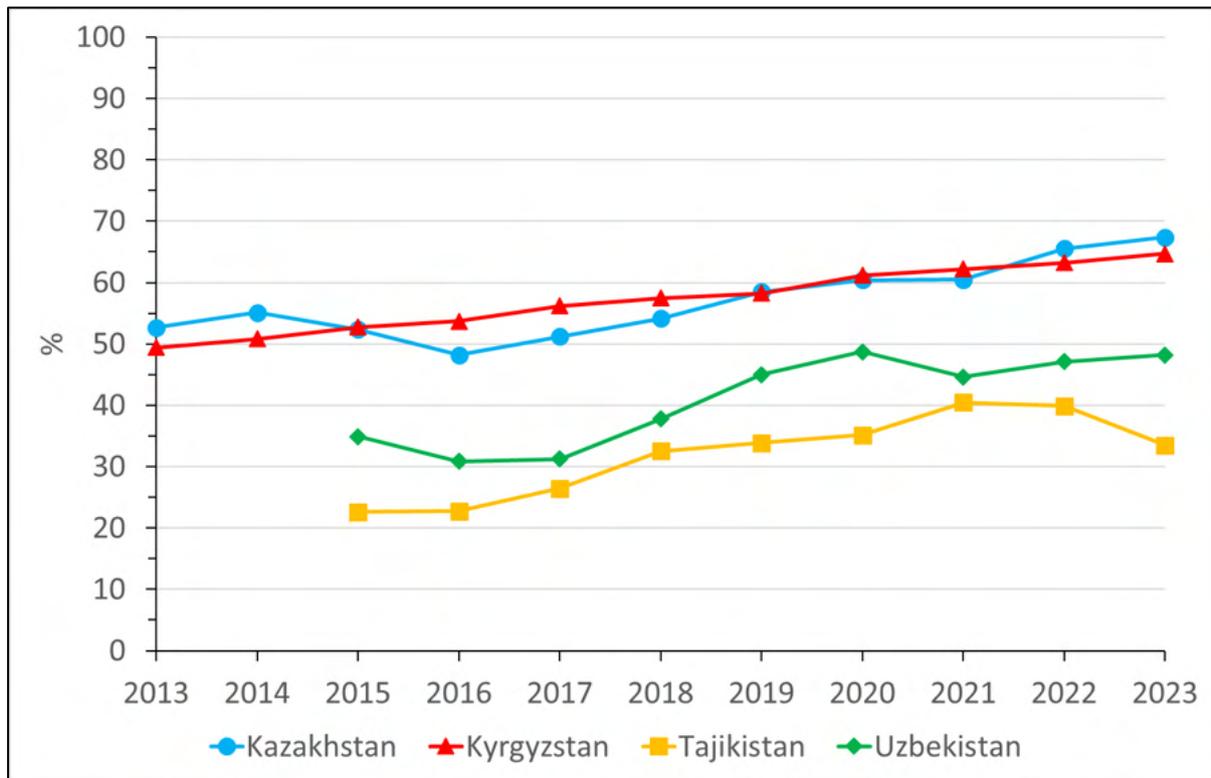


Figure 2 Share of modern retail outlets in total sales in four Central Asian countries, 2013-2023

Source: Authors based on data from national statistical offices.

Notes: National statistical offices report total retail sales composed of “trading enterprises” (labelled “modern retail outlets” here) and “individuals and street markets” or similar wording. Total sales include food, motor vehicles, fuel, household appliances, building materials, clothing, and other non-food items.

The evidence presented here suggests that transformation in agri-food value chains in Central Asia has lagged behind that of in other emerging economies in Asia. Yet an increasing role of modern retailers cannot be overlooked also in this part of the world. Over recent years, modern retailers gained market shares in all the four countries. In the following, we examine whether and how these aggregate observations are testimony of structural changes among livestock producers and intermediaries in four peri-urban settings.

3 The quest for a post-socialist farming model and the rise of individual farms and household producers

Once a supplier of meat, dairy products and animal fibre to the Soviet Union, the Central Asian livestock sector suffered severe reversals following independence (Robinson and Petrick 2021). Economic collapse combined with farm restructuring and asset privatisation, the breakdown of feed supply chains, long distance grazing management and veterinary systems led to plummeting productivity and,

especially in Kazakhstan, loss of a large proportion of the national herd (Figure 3). With the disappearance of inter-republic trading links within the Soviet Union, marketing became a domestic and even local affair during the 1990s.

What then should become the future model of livestock farming in Central Asia? Livestock systems in other parts of the world are quite heterogeneous (Steinfeld et al. 2006) and thus provide little intuitive guidance. Value chain transformations in the Western hemisphere have led to the emergence of highly specialised, quasi-industrialised livestock operations, typified by cattle fattening in the United States (MacDonald 2018). Here, pasture-based ranching systems specialise in distinct production stages according to the age of the animal, whilst animals in the later stages are fattened with purchased feeds in huge feedlots, often running their own mills (Crespi and Saitone 2018). In the earlier animal growth stages for beef production, as well as in dairy production in general, commercialisation processes have been less disruptive to traditional grazing systems worldwide, as most animals are still kept in family-owned businesses today (MacDonald 2018).

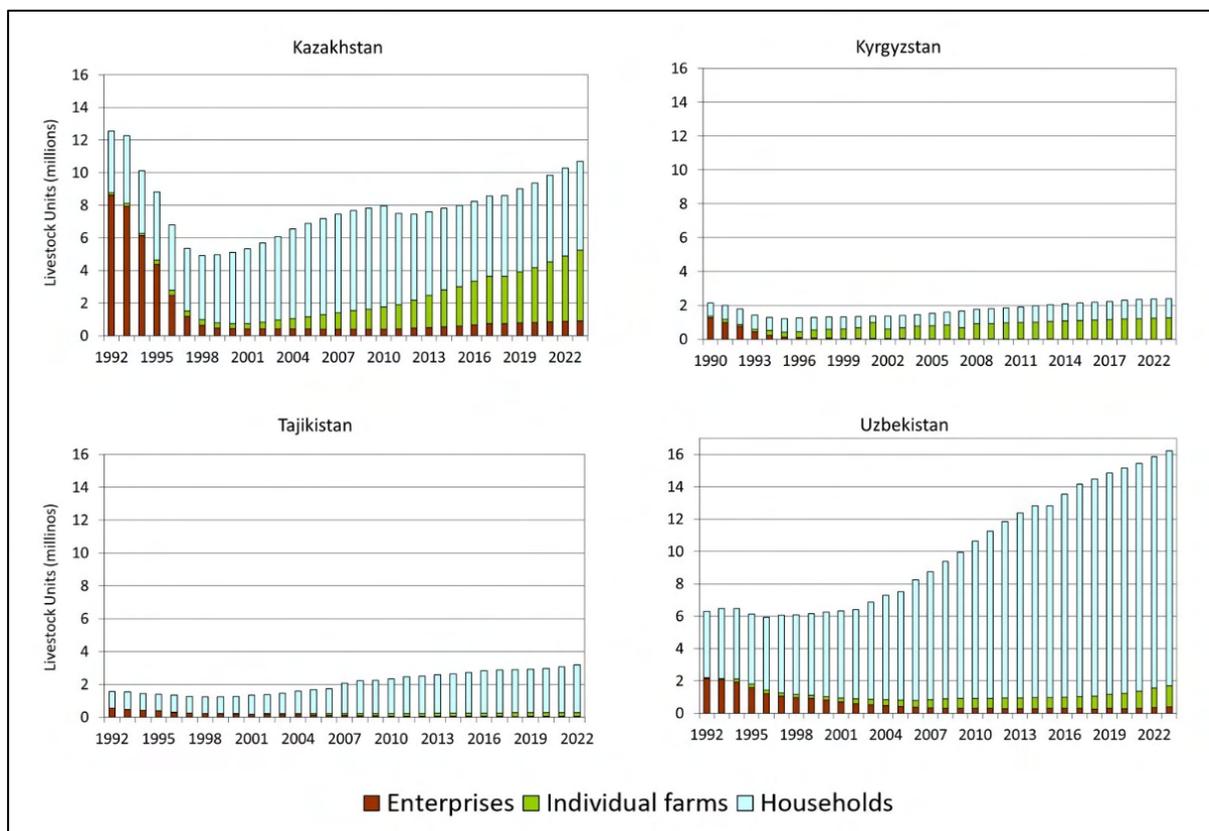


Figure 3 Dynamics of livestock numbers by farm type in four Central Asian countries

Source: Djanibekov and Petrick (2024) updated with data from national statistical offices.

Notes: Livestock numbers including cattle, sheep and goats converted to units using equivalents based on Eurostat (2024).

In all Central Asian republics, the three basic types of agricultural organisations are corporate enterprises (E), registered individual farms (F) and households (HH). In terms of land, households typically hold only kitchen gardens, although many in Tajikistan and Uzbekistan received additional areas through presidential decrees. Households have access to pastures in various ways and sublease land from farmers. Enterprises often started out as privatized state farms. Subsequent breakdown of these into farms occurred at different speeds in each republic and usually involved distribution of land shares to former workers (Petrick 2021; Robinson and Petrick 2021, 11-21).

In Kazakhstan and Kyrgyzstan, about half of the animals are currently owned by individual farms and enterprises (Figure 3). Since political independence, (mostly family operated) individual farms have gained notable shares in livestock numbers and output. This trend reflects a generally more liberal farm restructuring approach in both countries (Petrick 2021). The Kazakhstani government has increasingly included individual farmers in its subsidy programme (Robinson et al. 2021, 5). We explore below whether this has indeed led to increased value chain integration of individual farms. In a separate section, we analyse the state of large-scale livestock enterprises.

Taking together the four Central Asian countries studied here, by far most farm animals are kept by rural households today (Figure 3). In Tajikistan and Uzbekistan, households own roughly 90% of all cattle, sheep and goats, in Kyrgyzstan about 50% and in Kazakhstan 40%. Moreover, in the former two countries, absolute inventories in households expanded massively over the past two decades, and animals in households may be underreported in all countries. Compared to the first year of observation in our data, animal numbers in households in Tajikistan rose 2.8 times. In Uzbekistan, they rose 3.6 times and, on current growth trends, will soon have quadrupled. The ratios are 1.7 in Kyrgyzstan and 1.5 in Kazakhstan.

At least for Tajikistan and Uzbekistan, these numbers profoundly call into question the narrative of post-Soviet rural households as a stagnant, static farming entity, as suggested for Russia and Kazakhstan by Petrick and Götz (2019) or Wegren (2015). Given the widespread impression that households mostly produce for subsistence needs, face severe constraints in fodder access and are hardly integrated in market outlets, the massive expansion of animal numbers in households is puzzling indeed. But does it mean that these smallholders are participating in commercialised agri-food value chains? We will investigate below to what extent the perception of households needs to be revised.

4 Data and methods

The remainder of this study is based on data collected at four research sites representing peri-urban livestock value chains in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. The chains studied here are linked to pastoralist farming systems located at the foothills of the Tien Shan and Zarafshan mountain ranges in Central Asia (see Figure 3). In Kazakhstan, the site covers areas relatively close to Almaty but is also highly pastoral, with mainly rainfed or poor-quality arable land. The Kyrgyz site, in Chui province lies close to Bishkek, with both access to irrigated lands and high pastures in the Tien Shan mountains. The Tajik site is located between the northern city of Khujand and its mountainous hinterland in Sughd province. In Uzbekistan the data was collected in Kashkadarya province, close to both mountain pastures and the markets of Shahri-sabz and the more distant Samarkand.

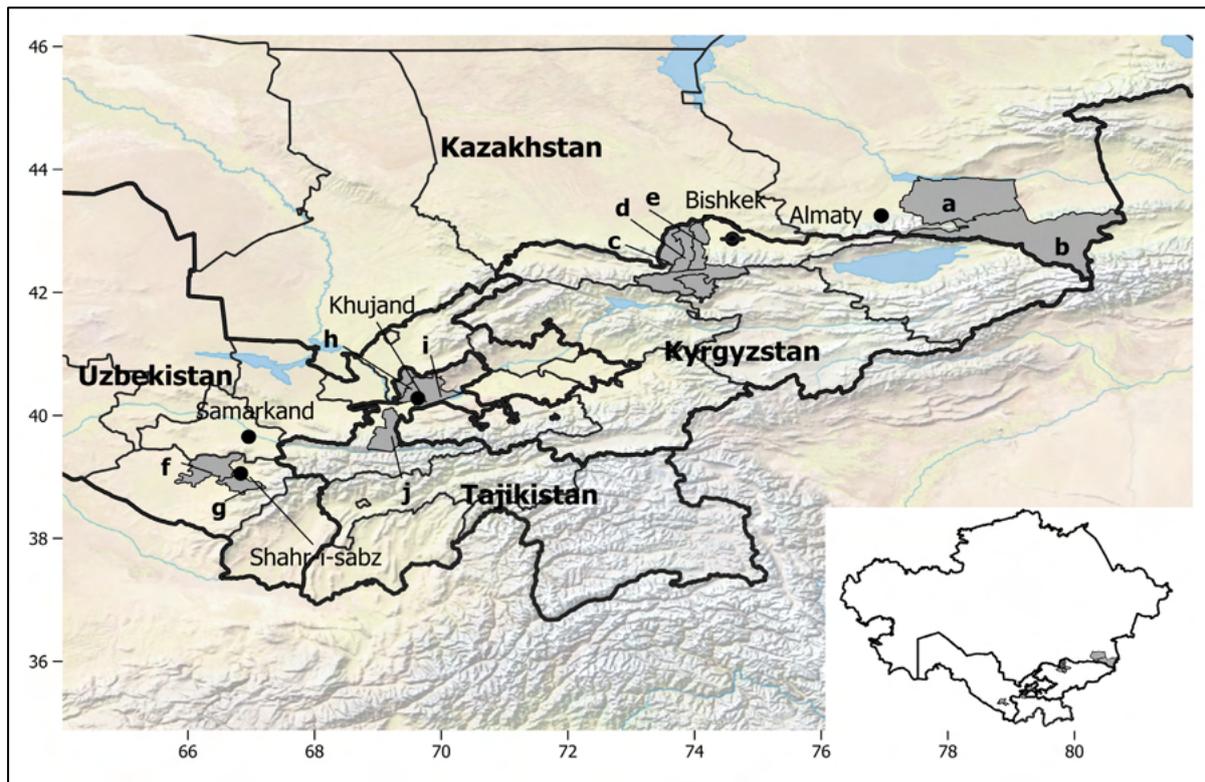


Figure 4 Location of study districts in the four countries

Source: Authors.

Notes: District names: (a) Enbekshikazakh; (b) Raiymbek; (c) Panfilov; (d) Jail; (e) Moskov; (f) Chirokchi; (g) Yakkabogh; (h) Mastchoh; (i) Gafurov and (j) Devashtich. At the Kyrgyz sites, polygons in grey south of named districts constitute pasture areas allocated to those districts.

The Kazakh site ranges from 100 to 300km from Almaty, with far smaller settlement sizes (Table A 1 in supplemental appendix). Tajikistan is the warmest and driest site and also the most urbanized, with the average distance of surveyed settlements only 38km from Khujand, and mean settlement size of almost 30,000 people.

Quantitative data comes from standardised farm and household surveys conducted in Kazakhstan, Kyrgyzstan and Uzbekistan in 2018 and in Tajikistan in 2020. In all countries except Kyrgyzstan (where households and farms were equally common) the sample was stratified into households and farms; in Uzbekistan, farms were stratified further into mixed and livestock-specialized groups, all selected from separate lists. In all four countries, only households and farms owning cattle were sampled, with the Kyrgyz sample restricted to those owning five or more head and Tajik households and farms to those having 2 and 15 head respectively. Table 1 presents the final sample at each site by farm type, see Appendix A1 for further sampling details. In addition to data from the survey questionnaire itself, geographical variables such as settlement size, distance to the nearest large city and altitude were generated for respondent locations using methods described in Appendix A2.

Table 1 Sample size by country and farm type (frequency)

| Country | Farms | Households | Livestock farms | Mixed Farms |
|------------|-------|------------|-----------------|-------------|
| Kazakhstan | 200 | 50 | | |
| Kyrgyzstan | 131 | 119 | | |
| Uzbekistan | | 152 | 76 | 73 |
| Tajikistan | 154 | 148 | | |

Source: Authors based on farm surveys.

All results are shown stratified following the sampling regime (Table 1; Appendix A1). Although the Kyrgyz sample was not stratified by household and farm, the sample is roughly equally split between the two and those results are presented separately. In figures and tables, the categories are shortened as follows: Kazakhstan household and commercial farms: KZ-HH, KZ-F; Kyrgyzstan households and commercial farms: KG-HH and KG-F; Tajik households and farms: TJ-HH, TJ-F; Uzbek households, mixed farms and livestock farms: UZ-HH UZ-MF UZ-LSF.

Survey data were supplemented with desk research based on publicly accessible information sources as well as qualitative fieldwork at the four sites. In Kazakhstan in-depth interviews were conducted with 20 producers representing a subset of the survey sample; with local district officials responsible for agriculture and pasture use planning and with buyers and sellers in three livestock bazaars. Near Bishkek, 11 milk producers, 2 milk collectors and a veterinarian were interviewed in order to explore the institutional arrangements for milk marketing. In Tajikistan, interviews focussed on value chains and included 12 milk producers (7 farms and 5 households), 6 animal fatteners, 2 butchers, 2 representatives from a slaughterhouse, 6 animal traders, 8 milk collectors, 4 representatives from dairy processing enterprises, and a veterinarian. Three focus-group discussions were held with livestock producers and one with milk traders. In Uzbekistan, 31 in-depth interviews were conducted with farmers and farmers' councils, milk collectors, processing plant managers, feed suppliers, dairy retailers, employees of district government, veterinarians, livestock specialists, and a bank specialist. These core interviews were conducted in the same years as the surveys. Qualitative information was collected and updated during shorter field visits to all four regions in 2015, 2020, 2022, 2023 and 2024.

5 Feeding strategies, pastoral land use and performance indicators in the study sites

A key pattern in livestock value chain transformations worldwide is their association with intensification via enhanced feeding, thus leading to higher animal productivity. At the same time, intensification on pastureland, as prevalent in Central Asia, is technically more difficult and often less profitable than on arable land (Steinfeld et al. 2006, 510). While many grassland farming systems in arid regions and low-income countries have intensified over recent decades, productivity increases per grazing area were mostly due to increased stocking rates, not increasing animal productivity (Godde et al. 2018, 100). Here we give an overview of current herd structures, feeding practices and performance indicators among the households and individual farms in our sample.

5.1 Herd sizes and land use

Across all sites, the bulk of households hold 10 livestock units (LU) or less, whilst most farms own more than 10 (Table 2). Median LU per producer are highest in farms at the pastoral site in Kazakhstan as well as in Uzbek specialized livestock farms; and lowest in Uzbek households. At the same time, each group includes a small number of producers with very large livestock holdings. There is substantial overlap between household and farm holdings, particularly in Kyrgyzstan. The sampling strategy excluded Kyrgyz households with less than five heads of cattle. Cattle make up over 80% of livestock units in all groups with the exception of producers in Kazakhstan and farms in Kyrgyzstan, which hold more small stock and horses than other groups.

Households have very limited access to crop and hay land, with medians of less than one hectare at all sites (Table 2; see Figure A 1 for national level). An exception is Kazakhstan, where large areas of hay land are available. In Kyrgyzstan, a small fraction of households has very good access to land. Farms typically have access to cropland several orders of magnitude greater than that of households. Considering crop plus hay land availability on a per-head basis (not shown), disparities in land access are much smaller. In general, Uzbek households have significantly lower access to land (total and per head) than other groups.

Table 2 Descriptive statistics of survey sample

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|--|-------|-------|-------|-------|-------|--------|-------|-------|-------|
| N (sample) | 50 | 200 | 119 | 131 | 152 | 76 | 73 | 148 | 154 |
| Owning cattle % | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Owning small stock % | 74.0 | 91.0 | 46.2 | 63.4 | 50.0 | 84.2 | 52.1 | 46.6 | 55.8 |
| Access to hayfields % | 52.0 | 71.5 | 8.4 | 13.0 | 7.2 | 17.1 | 4.1 | 17.6 | 40.3 |
| Livestock ownership (units) median | 8.1 | 23.9 | 7.4 | 12.4 | 2.7 | 38.8 | 5.8 | 3.0 | 11.8 |
| Livestock ownership (units) max | 45.0 | 645.0 | 53.2 | 180.0 | 99.9 | 176.6 | 36.8 | 45.8 | 290.0 |
| Crop and hay land (ha) median | 2.8 | 9.8 | 0.3 | 7.5 | 0.1 | 25.0 | 41.0 | 0.5 | 2.8 |
| Crop and hay land (ha) max | 80 | 490 | 39 | 250 | 39 | 370 | 100 | 9 | 60 |
| Uses pedigree bull % | 10 | 18 | 13 | 8 | 50 | 63 | 49 | 20 | 31 |
| Uses artificial insemination % | 4 | 2 | 34 | 27 | 11 | 36 | 19 | 3 | 5 |
| Produces milk % | 90.0 | 88.0 | 84.9 | 89.3 | 84.2 | 88.2 | 93.2 | 86.5 | 98.7 |
| Annual milk yield per cow (l) median | 600 | 825 | 2,250 | 1,920 | 1,500 | 1,900 | 1,800 | 1,000 | 1,250 |
| Annual milk yield per cow (sellers only, l) median | 810 | 900 | 2,400 | 1,920 | 1,800 | 1,950 | 1,850 | 1,065 | 1,400 |
| Weight of male cattle at sale (kg) median | 150 | 180 | 200 | 288 | 283 | 320 | 350 | 251 | 365 |
| Age of male cattle at sale (months) median | 18 | 18 | 16 | 20 | 23 | 27 | 28 | 24 | 24 |

Notes: Figures for sales weight are aggregated over all age groups, weighted by number sold in each group and also corrected for errors related to age categories.

Source: Authors based on survey data.

Pasture areas are not shown in the table because these are accessed under a range of formal and informal arrangements and areas are therefore not always known by users. Many producers use grazing land directly around the village, a resource particularly important for smaller holdings. Around 90% of Kazakh households use village pastures, which is demarcated and designated as common in that country. At other sites, many villages are surrounded by agricultural land so frequency of access to this resource is around 50% in the Chui valley and lower at the Uzbek and Tajik sites.

Pastureland beyond the village is usually of higher quality and may be accessed through a number of arrangements. Many lands are grazed collectively or under informal arrangements, so rather than examining areas in hectares (which are usually unknown) we measure frequency of off-village (remote)

pasture use, a measure of livestock mobility. Data for the use of such pastures by cattle (Figure 5) confirm that by far the most mobile group are Kazakh farmers, with Uzbek livestock farms and Kyrgyz farms having moderate mobility frequency between 30 and 40%. Tajik farms are surprisingly sedentary with only around 17% saying they move their cattle to remote pastures over the year. However, others (not counted as mobile here) move to outlying farmland, whilst small stock are more likely to be sent to pasture. Cattle belonging to households are less likely to be sent to remote pastures than those of farms, but the magnitude of the difference at the Kyrgyz and Tajik sites is small. In some groups (at Kazakh and Uzbek sites) more producers are mobile than have tenure over pasture, reflecting various informal methods employed to access this resource (Robinson and Petrick 2024). Likelihood of cattle movement in the Kyrgyz and Tajik samples depends heavily on location, with a higher rate of mobility among residents of mountainous areas.

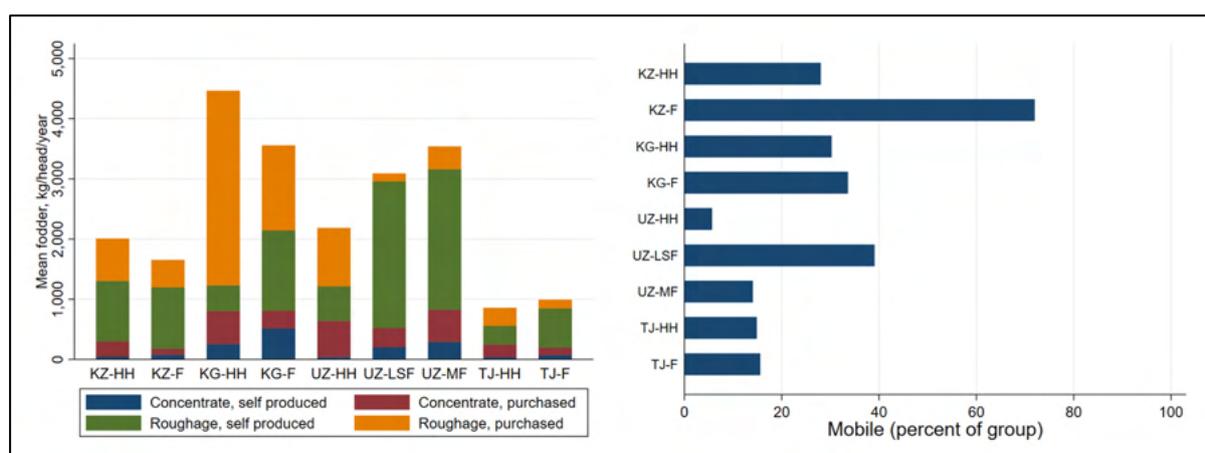


Figure 5 Composition of fodder rations provided to cattle (left) and pasture access (right)

Source: Authors based on survey data.

Notes: Pasture access (right panel) measured by percentage of producers having sent cattle to remote pasture during 12 months before the interview.

5.2 Fodder intake and feeding strategies

Households provided larger mean fodder quantities per head of cattle than commercial farms in Kazakhstan and Kyrgyzstan (Figure 5). This may be related to constraints (for example pasture access among Kazakh households) or incentives (the focus on milk sales by households near Bishkek). In contrast, at the Uzbek site farms provide more fodder overall to cattle than households, whilst in Tajikistan rations are similar and very low, reflecting both the land constraint and an apparent inability to compensate through fodder purchases. In all cases, households must provide more purchased roughage and concentrate than farms and frequency of self-produced fodders are far higher among commercial farms.

Herd-level fodder provision figures may conceal a range of feeding patterns. Many producers provide only roughage to the bulk of their animals, fattening a small number of bullocks on concentrate for a few months. Others engage only in short-term purchase and re-sale. A high proportion of Kyrgyz and Tajik farmers purchase cattle (Table A 5), most of which are bullocks and calves respectively, and over 60% of households and farms at the Bishkek site have at least some animals stall fed all year around

(Table A 3). This suggests that many producers are following a purchase-fatten-sell strategy. In Tajikistan, although questions on stall feeding were missing, around half of the 141 respondents selling cattle fattened them on concentrate beforehand - with a frequency higher among farmers than households. At this site, land for producing fodder is a severe constraint: a large milking enterprise interviewed purchased almost all its fodder, whilst the main combined feed factory in Khujand imports virtually all ingredients from abroad. The area also lacks pasture, with many producers focusing on the finishing of grass-raised cattle from Kyrgyzstan. Thus, the business model tends to be purchase of young stock, fattening, and sale, using purchased feed for no more than 3-4 months due to the high cost of this input. Those with access to pasture prefer to invest in calves for raising on grass before selling on for fattening. The larger and more pastorally oriented Kazakh (and some Uzbek) livestock farmers are more likely to purchase breeding animals, rather than younger stock for fattening. However, over half of Uzbek livestock farms held at least some permanently stalled cattle, whilst the same figure was only 2% in Kazakhstan (Table A 3).

5.3 Genetic improvement

Genetic improvement is an important driver of animal productivity, but its effects depend on fodder provision and husbandry practices. In the survey sample, only in the Uzbek and Tajik groups do more than 20% of any farms or households use (own, hire or borrow) a pedigree stud bull (Table 2). Kazakh producers, focusing on pasture-raised meat, clearly place a greater emphasis on herd size than individual animal productivity than other groups, and those benefiting from subsidized bulls are mainly in the largest quartile (by holding size) of the farm sample. The low prevalence of pedigree breeds at the Kyrgyz site is surprising given the importance of milk production, but this is partially offset by use of artificial insemination, which is used with very high frequency by households in particular.

5.4 Performance indicators

Performance indicators are generally low by international standards. No group exhibited median yields of more than 2500l (Table 2), which is in line with national averages (Figure A 2) and about one quarter the average milk yield in Canada and one third of it in France (FAO 2024). Individual respondents at Kyrgyz and Uzbek sites report yields over 6000l per year. Milk yields are especially low at the Kazakh and Tajik sites, consistent with low fodder intake (Figure 5). Assuming meat yields of around 50%, carcass weights may be only around half of those in France or Canada, which were over 300kg in 2022 (FAO 2024).

There is little evidence from the survey data that milk yields on farms are higher than those in households, with the exception of the Uzbek site (Table 2; Figure A 13). Yields are even slightly higher in Kyrgyz households (on average closer to Bishkek and more specialized in cattle raising) than on farms. Efforts to improve genetic potential do not always result in improvements: near Khujand, imported Russian milk breeds, which should give 30-40 liters per day, may yield only 10-15 under local conditions. At the Kazakh site, only ten percent of the sample sold any milk, with others using it only for family consumption and for calves and resulting in higher reported yields among those selling.

In contrast to the pattern for milk yields, all farms sell cattle at higher weights than households at the same site (Table 2; Figure A 14). Households tend to sell males at a younger age, suggesting an inability to feed them to mature slaughter weight.

5.5 Summary

Our data draws a picture of fragmented production structures, modest intensity levels determined by fodder constraints in most producer subgroups and access to high-yielding pasture resources at some sites only (Kazakhstan and Kyrgyzstan). The evidence on deficient winter feeding and low performance indicators exhibits a striking similarity to studies carried out more than a decade earlier, such as Petrick et al. (2014) on Kazakhstan,³ ur-Rahim et al. (2014) on Kyrgyzstan, Sedik (2009) on Tajikistan and Lerman (2008) on Uzbekistan. It is also consistent with persistently low shares of arable land devoted to fodder crops in all Central Asian countries (Robinson and Petrick 2021, 42; Figures A3 & A4). When asked about the most important barriers to the expansion of their beef or milk production, by far the most frequent response in our surveys here was lacking access to pastures, arable land for feed production, or other fodder sources (Table A 8). Among the Uzbek producers, up to 80% raised the latter two concerns, while pasture access concerns were quite prominent in Kyrgyzstan and Tajikistan.

In light of strongly rising animal numbers during the previous decade (Figure 3), we conclude that the “transformation” of Central Asian livestock production at the farm-level mostly involved the multiplication of a more or less precarious feeding model without any major changes in the nature of the farming system. Our analysis thus confirms the challenges in intensifying pasture-based livestock systems highlighted by Steinfeld et al. (2006) and Godde et al. (2018) and calls into question the arrival of any significant “revolution” of value chain structures among farms and households.

6 The anatomy of downstream value chains

Many transformations of agricultural value chains observed worldwide concern the stages between the farm gate and the consumer. New types of intermediaries provide capital-intensive logistics and processing services that better preserve product quality (Reardon and Timmer 2014). Together with wholesalers and retailers they enhance vertical coordination along the value chain through instruments such as contract farming or resource providing contracts, in which primary producers obtain inputs, extension and technology support in exchange for delivery obligations (Dries et al. 2009; Reardon et al. 2009).

In the following, we assemble the available evidence on new types of market relations, emerging actors and stages along the value chain and contractual arrangements within the livestock value chains under study in Central Asia. A first question to address is to what extent the many atomised producers do participate in output market relations at all.

6.1 Market participation by producers

Our survey data exhibits considerable heterogeneity in market participation among livestock producers, and if they participate, their marketing channels are quite diverse (Figures A15-A22). A high percentage of farms and households near both Bishkek and Khujand sell raw milk (Figure 6). In Uzbekistan, the frequency of milk sales is similar to those of Kyrgyzstan and Tajikistan only among large livestock

³ Performance indicators reported by Petrick et al. (2014) for dairy producers in Almaty and Akmola provinces in 2003 and 2011 were actually showing higher slaughter weights and milk yields than the ones given in for 2018 in Table 2.

farms; in households and mixed farms, it is much lower. The figures emphasize the commercial nature of milk production in both Kyrgyz groups (where the smallest herds were not surveyed) and Uzbek livestock farms. Other Uzbek and Tajik producers display medium levels of market integration, while Kazakh respondents make little use of milk markets (Figures A15, A19). Near Almaty there are a number of large modern milking enterprises (see below), and milk processors tend to be located in Almaty itself. Smallholders with milking cattle living close to the city are increasingly rare. In the Kyrgyz Chui valley processors are more widely distributed, in areas with high densities of smallholding milk producers (Figure A 20).

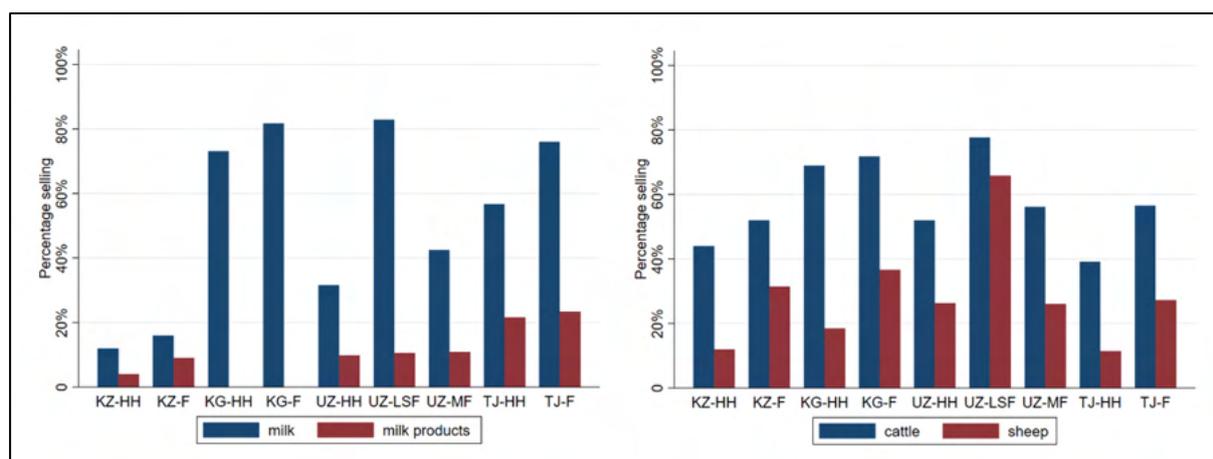


Figure 6 Share of cow owners selling milk (left) and cattle owners selling cattle or sheep (right)

Source: Authors based on survey data.

The proportion of respondents selling live cattle is over 40% for all groups, with the exception of households in Tajikistan, and reaches over 60% for specialist livestock farms in Uzbekistan and both groups at the Kyrgyz site (Figure 6). Sheep sales are less prevalent, at around 25% or less for all groups. Numbers of animals sold (Table A 5 and A 6) appear generally low, with mean cattle sales of around 1-3 for households and 5-7 cattle per farm and year (with the exception of Tajik farms, which sell less). Mean sheep sales range from 2 to 7 for households, but taking sellers alone figures are higher, particularly in Kazakhstan. Sales of beef or other meat (Figure A 7), which require access to an abattoir are important only in Uzbekistan whilst only at the Kazakh site do producers of any type sell wool, skins or cashmere with high frequency (Figure A 8).

6.2 Marketing channels and vertical coordination

The two main livestock value chains relevant in our study sites are for dairy products and live cattle, which we study in turn. Figure 7 presents a schematic structure of the dairy value chains in current-day Central Asia. The dominating elements and sales channels vary across the sites, which we discuss below.

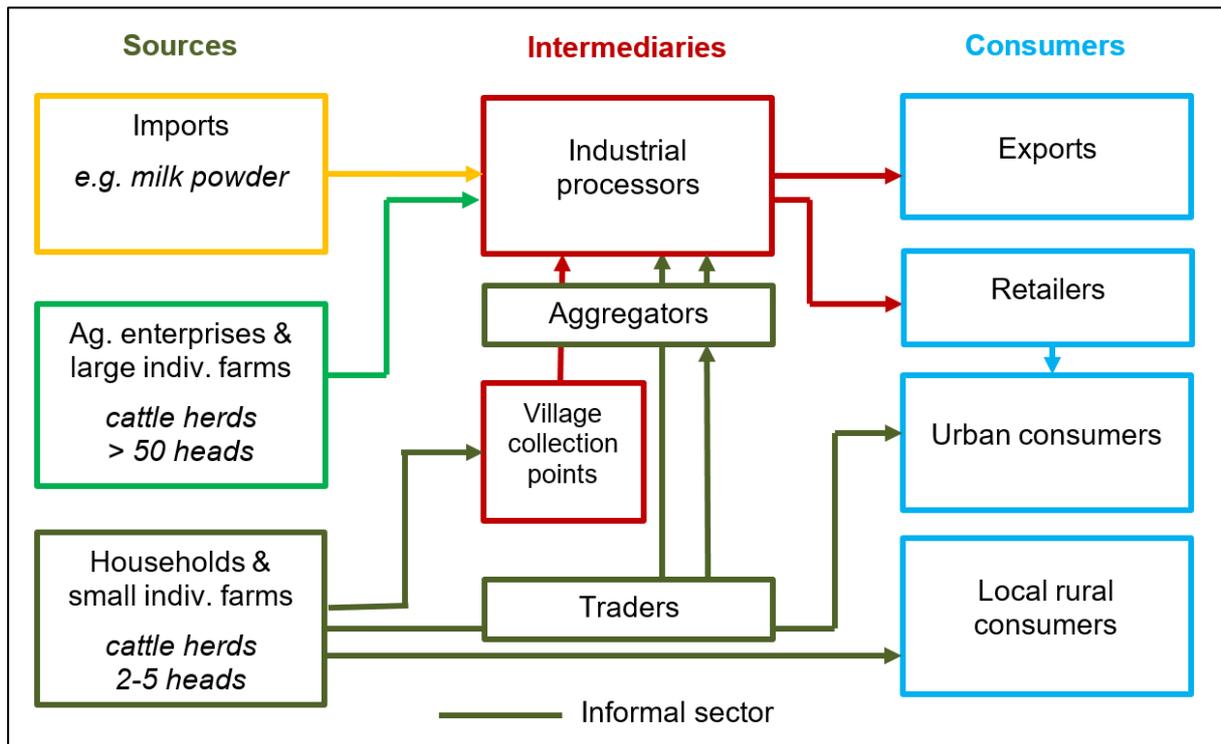


Figure 7 Structure of dairy value chains in Central Asia ca. 2020

Source: Authors updated from Petrick et al. (2014, 21).

Near Almaty in Kazakhstan, dairy value chains are bifurcated into home processing for self-consumption or sale to neighbours and traders, and large urban processing plants purchasing milk collected from large area around the city, but also using imported powdered milk. Although some supply chains work through direct farm collection, others include both a pool and trader which together take over 35% of the price paid by the processor (Oshakbayev and Bozayeva 2019). Of the small number of sampled milk sellers, the majority sold through such intermediaries, with a smaller fraction selling to neighbours and at local markets (Figure 8). There are few decentralized plants in the study districts, so sales were limited mostly to producers close to Almaty, however village collection points with milk coolers allow a small number of communities to join milk value chains up to four hours' drive from the city.

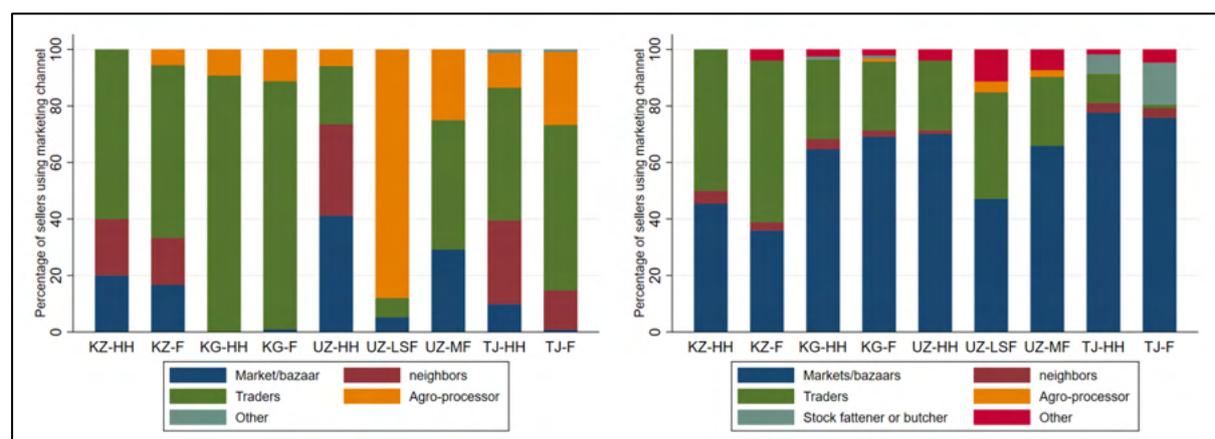


Figure 8 Marketing channels for milk (left) and cattle (right)

Source: Authors based on survey data.

In the Chui valley of Kyrgyzstan, milk producers of all scales sell to one of five processing plants through a chain of village-level traders. This system is well developed enough that few farms sell through any other channel (Figure 8). These traders sell on to intermediaries who aggregate the milk before selling to processors. Traders represent an oligopoly or cartel, forming long term relationships with clients based on trust, erecting barriers to new entrants in their territory, and using various coercive methods to dissuade clients from side-selling. This reduces competition and allows them to control prices. Although in our survey sample there were few such cases, for larger farmers, processors will send a milk tanker to pick up milk directly, but these demand 100-200kg per day to make this worth their while. Therefore, milk from those owning 2-3 cows (10-100l) per day are collected by traders which either sell on to higher up (secondary) intermediaries working directly for the processor, or to a milk collection and cooling point. Although these points do exist in some villages, they were not used by survey respondents (Table 3).

In Kashkadarya (Uzbekistan), few households are connected to large-scale processors, even through intermediaries, and sell largely in the market and to neighbours (Figure 8). In contrast, around 80 percent of livestock-specialized farms sell directly to processing enterprises, a sales pattern much rarer at the other sites. Some processors prefer to keep their own dairy herd, buying additional milk from households and farms, or maintain long-term relationships with milk traders (Naumov and Pugach 2019), but the importance of such intermediaries is clearly much lower at the Uzbek site than in the Chui valley.

In Sughd province of Tajikistan, where over 20 officially registered dairy processing enterprises compete for raw milk, plants also source raw product either directly from milk producers or (more commonly) through milk traders (Figure 8), however some have their own farms (see section on enterprises below). As near Bishkek, traders monopolize collection in specific territories, excluding other buyers and keeping milk prices low. However, they also maintain long-term relationships with producers based on trust, as well as providing a number of services (see section on contracting below). Only a small fraction have formal contracts with processors and reluctance generally comes from the traders themselves, who fear inspection. Plants often enforce stringent standards, causing some traders to

open their own small processing facilities to process rejected milk. Meanwhile, processors operate below production capacity due to shortages in supply of high-quality raw milk, which is thus supplemented with imported milk powder (Figure 7). Both traders and smaller dairy plants use non-refrigerated milk transportation, whilst only larger plants have invested in cold chains.

Across the sites, the sale of milk products processed at home is dominated by direct sales to consumers (in bazaars and to neighbours). Within-site comparisons suggest that this activity tends to be more common far from raw milk markets (Kazakhstan) or where electricity shortages are common (Tajikistan). It is zero near Bishkek, where both of these constraints are weak and where mere subsistence producers were undersampled.

In all countries, and for both households and farms, the majority of marketing channels for live cattle are district or provincial bazaars (usually district level) and mobile traders, the latter being particularly important at the Kazakh site where many producers live far from markets (Figure 8). In Kazakhstan and Kyrgyzstan, intermediaries commonly buy livestock in one region and resell them in another, based on differences in price, live weight or meat quality. In bazaars a common arrangement (particularly in Sughd) are chains involving brokers who mediate between producers and abattoirs/butchers, that in turn are primary suppliers of beef to meat processors. Livestock may thus change hands several times on one day in the same market. Other purchasers in bazaars include farmers looking for breeding stock and small feedlot owners purchasing animals of fattening age. Transmission of market information and transactions are also increasingly carried out online. However, there is little formal vertical coordination involving producers directly and these are aware only of the first stage in the value chain. Sales concern almost exclusively live animals; only Uzbek livestock farms sell beef in any numbers, of which only 16 % deal directly with processors (Table A 7).

6.3 Contracting and cooperatives

Interviews in both Kyrgyzstan and Tajikistan suggest that milk traders have prior agreements with sellers and buyer-purchaser relationships based on trust may last many years. In Sughd, only very well-established dairy plants seek to establish formal milk purchasing agreements directly with producers. Plants note a reluctance among both producers and traders to engage in formal contracts, which have led some to invest in cooperatives, milk collection centres or eventually their own farms. In the cattle and beef value chain, vertical coordination may occur between brokers and fatteners, taking the form of joint investments rather than credit due to religious prohibitions on interest, but arrangements made directly with producers were not observed in our sample outside Uzbekistan. Among the specialised livestock farms there, more than 80% reported to have a formal delivery contract with a processor. Anecdotal evidence suggests that rural livestock entrepreneurs shortcut the value chains to urban high-value food service providers and restaurants by establishing direct marketing arrangements.

Despite the prevalence of verbal contracts based on trust, outside the implicit communication of quality information, the survey uncovered little evidence of goods or service provision (inputs, fodder or extension) through these relationships, or indeed from any processing or other purchasing enterprise at any site (Figure A 10). Concerning credit, the survey focused largely on loans taken for investments. Of those farms which had invested, none said they obtained credit from a buyer or processor. However, interviews in Sughd reveal that small loans are indeed supplied by traders for urgent needs such as veterinary medications, school supplies, wedding expenses, or funeral arrangements. Traders also

assist in purchasing and transporting items that are not readily available in the villages, such as vehicle spare parts or veterinary medications. In our study sites, the processing companies Foodmaster in Almaty and Afzali Zarzamin in Khujand were reported to provide milk cooling equipment and veterinary services, respectively.

In Kazakhstan, subsidies aimed at cooperatives were put in place to generate economies of scale and investment in infrastructure such as milk coolers and mini-abattoirs, but bureaucratic difficulties associated with cooperative establishment and subsidy receipt remain (OECD 2019). Cooperative membership in our sample is low and limited mostly to larger producers (Figure A 11). Barriers include in particular requirements to sell directly to feedlots or processors (for example milk cooperatives do not receive subsidies if they sell to traders); meanwhile accredited purchasers often require a price commission in return for signing papers required to receive subsidies. Among Kyrgyz and Tajik farmers, cooperatives were encouraged by policy makers and membership is common among farmers (Figure A 11). However, many may be 'false cooperatives' as few respondents appeared to sell products or receive goods or services through these organizations (Figure A 12). Interviews in Sughd suggested that cooperatives established under formal law are mostly inactive.

6.4 Product quality and standards

At the study sites, milk prices are often a function of quality. Prices depend primarily on fat and protein content, with highest quality milk about 40 % more expensive than lowest quality near Almaty (Oshakbayev and Bozayeva 2019). The quality of milk from smaller operations tends to be lower - for example, in Uzbekistan mean fat content of milk produced by households is 2 %, whilst the equivalent figure among farmers is 3.2–3.5 % (Naumov and Pugach 2019). Here, for processors levels below 3% are unacceptable, but may still be prevalent in bazaars, where checks are less stringent. These two-tier sanitary control systems lead to unfair competition, with modern dairies unable to obtain sufficient quantities of high quality raw milk, whilst lower-quality milk is sold elsewhere (IFAD 2015). Chains dominated by intermediaries carry considerable risk as these may check only for water addition and acidity or conduct visual inspection alone. A major source of contamination is the storage and transport of milk, which would be mitigated by village level coolers and cold chain infrastructure, leading to less wastage and thus higher prices for farmers.

Table 3 Milk quality and technology parameters

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|---|-------|------|-------|------|-------|--------|-------|-------|------|
| No. of producers in sample selling milk, among which: | 5 | 18 | 87 | 107 | 31 | 59 | 21 | 81 | 116 |
| Milk price depends on quality % | 50 | 34 | 1 | 3 | 77 | 26 | 66 | 52 | 55 |
| Operates cooling facility on farm % | 0 | 3 | 40 | 57 | 27 | 5 | 14 | 31 | 32 |
| Supplies milk to village pool % | 17 | 6 | 0 | 1 | 0 | 11 | 19 | 8 | 3 |

Source: Authors based on survey data.

Unlike the other sites, close to zero milk sellers near Bishkek reported a link between milk quality and price (Table 3). The purchasing price is fixed and whilst traders do sometimes check the milk for fat content and density, low values result in non-purchase rather than a lower price. Control occurs higher up the chain, at the level of secondary intermediaries or processor. In Sughd, processors purchasing directly from producers conduct an initial physical assessment at the farm, with more detailed quality control procedures on arrival at the plant. Price incentives for quality are offered, but were apparently poorly understood by farmers. Where milk is supplied by traders, these are responsible for ensuring milk quality and safety, relying on rapid tests for quality (milk density, water and fat contents) and freshness (acidity); and visual inspection. Where trust is high, only visual inspections are carried out. Traders apply higher prices or bonus payments for higher quality milk. Nonetheless, interviews at processors suggest that only around 30-45% of the total milk purchased from traders exhibits satisfactory quality. The remainder is utilized for secondary purposes or rejected. Reasons for low milk quality may include the dearth of village-level cooling tanks and lack of uninterrupted cold chains (Figure 9).



Figure 9 Milking equipment and raw milk transport in Chui valley, Kyrgyzstan

Source: Authors 2018 (left) and 2022 (right).

Village coolers may mitigate some of these issues, but close to Bishkek these appear to be rare (which could be both a cause and consequence of the high coverage of trader networks). At the other sites, village collection centres are more frequent. In Uzbekistan, they are supported by government initiatives (Naumov and Pugach 2019), whilst in Kyrgyzstan donor-funded projects have also invested in some regions. In Sughd, although some collection points have been established, these are often economically unsustainable due to costs of electricity, cleaning detergents, labour and taxes combined with frequent power outages.

6.5 Summary

Livestock value chains in Central Asia are dominated by informal traders and sales points, often in the form of lightly regulated street markets and village bazaars. Within the chains, traders and middlemen are the informal coordination agents and often powerful gatekeepers. According to our evidence, many traders aim to reduce competition by spatial market segmentation. While processors, sometimes assisted by donor projects, promote alternative sales channels via direct aggregation or village collection points, formal contracting remains rare and average product quality is low. Hardly any traders or processors provide inputs, fodder or extension services to producers on a contractual basis, which is consistent with the presence of market power (Swinnen et al. 2007, 77). In many cases, the more appropriate term for the prevailing value chains seems to be that of a fraying web of often local sales channels leading to varied end consumers of livestock products, as illustrated for the case of Tajik producers in Figure 10.

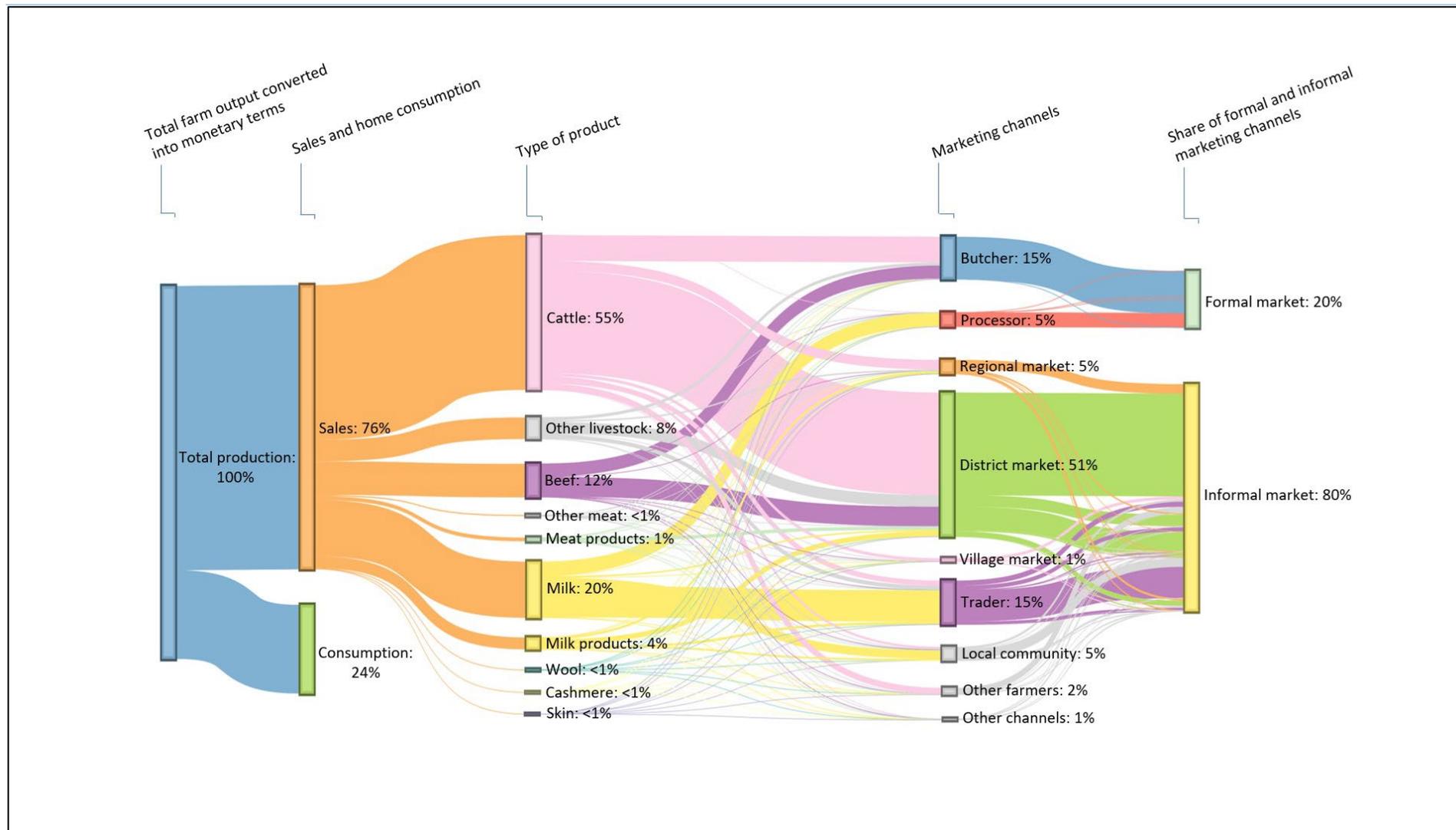


Figure 10 Structure and sales channels of livestock output among producers in Tajikistan

Source: Authors based on survey data.

Notes: Produce and sales for individual farms and households combined. Aggregation by prices reported by individual respondents. Similar diagrams for individual farms and households by study site are given in Figures A15 to A22.

7 Large-scale livestock enterprises and feedlots

Since the collapse of collective and state-owned livestock operations across Central Asia, the future of large scale production units has been a matter of controversial debate (Petrick 2021). Figure 2 suggests that few animals are now kept in agricultural enterprises, consistent with the policy goals of full de-collectivisation and farm restructuring. Yet policymakers across the region have continued advocating for large scale commercial dairy production and bull fattening as business strategies that would propel economic diversification and export revenues (e.g. FAO 2010). Even so, the commercialisation of value chains may raise concern if large enterprises drive out smallholders as suppliers to lucrative sales channels (Barrett et al. 2022, 1351-1353). In Eastern Europe in the 2000s, processing companies included small farmers in emerging value chains only if no relevant supply was available from larger farms, as the latter allowed contracting at lower cost and provided higher quality produce (Dries et al. 2009, 1749-1752).

So how do large enterprises fare in our Central Asian study regions today? Official statistics at the national level show that the share of enterprises in primary meat production is generally low and exceeds ten percent only in Kazakhstan and Tajikistan. The shares in milk production are even lower (Figure 11).

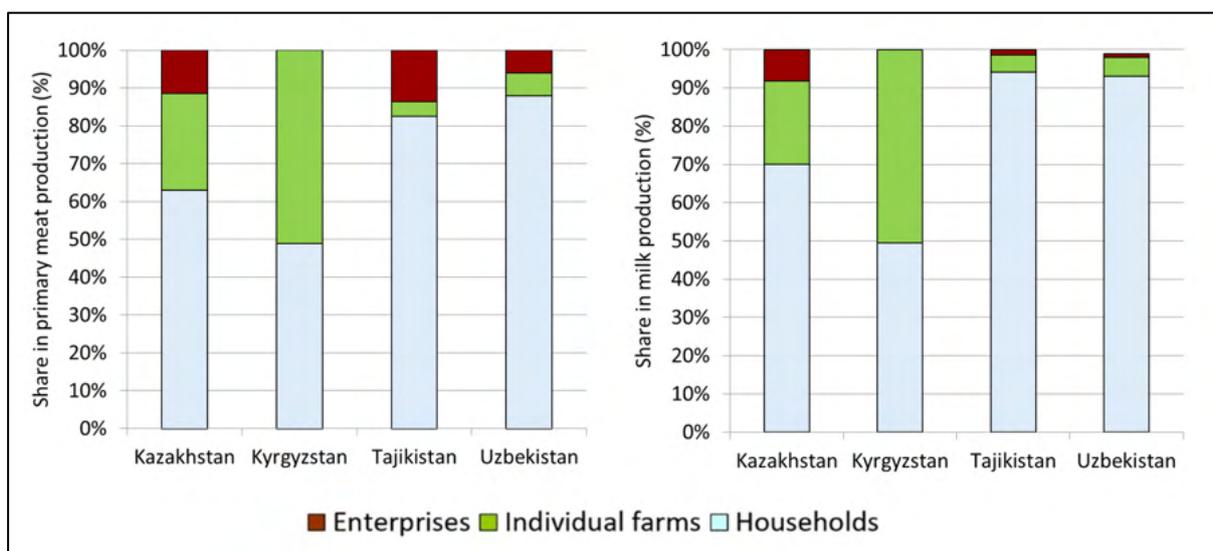


Figure 11 Primary meat (left) and milk (right) production by farm type in four Central Asian countries in 2022

Source: Authors based on data from national statistical offices.

Notes: Farm-level meat production measured in slaughter weight of all types of livestock and poultry.

As our farm surveys covered no agricultural enterprises, we conducted a series of case studies among corporate meat and dairy producers in Kazakhstan and Tajikistan (Table 4), based on a convenience

sample. We included both meat and dairy enterprises that were locally active in our study regions and accessible for researchers, as well as one nationally prominent enterprise in each country (Elim-Ai Kokpekty in KZ and Marmari in TJ). Figure 12 illustrates some typical production structures. Wilkes and Merger (2014, 40) mention the existence of feedlots with 100 to 500 heads of cattle in the Chui valley in KG. Some of the specialised livestock farms in Kashkadarya in UZ analysed above also appear to come close to this category.

Table 4 Examples of large livestock enterprises in Kazakhstan and Tajikistan

| Enterprise name | Country, province | Production focus | Number of animals | Key feeding source | Vertical integration | Main marketing channels | Year of data collection | Online sources |
|------------------------|---------------------------|------------------|--|--|--|--|-------------------------|---|
| Zhana Aktasty | KZ Almaty | Cattle feed-lot | 1,000 cattle | 2700 ha own cropland, grazing | Own processing plant established in 2023 | Kazmyaso retail network in Almaty | 2018, 2023 | https://kazmyaso.kz/about-us |
| Amiran | KZ Almaty | Dairy enterprise | 2,000 cattle incl. 780 cows | 2000 ha own cropland | Own processing plant (baby food), own brand | Food retailers in Almaty, some brand stores | 2015, 2024 | https://amiran.kz/nasha-ferma |
| Elim-Ai Kokpekty | KZ Abai (East Kazakhstan) | Cattle feed-lot | 10,000 cattle in two breeding farms & several feedlots | 25,000 ha cropland & hayfields, grazing | Own slaughterhouse, sourcing young cattle from smaller farmers | Export of live animals to neighbour countries, food retailers in Astana and Almaty | 2024 | https://eldala.kz/dannye/kompanii/1019-elimaj-kokpekty |
| Afzali Zarzamin | TJ Sughd | Dairy enterprise | 500 cattle incl. 180 cows | Purchased from neighbour farmers or feed mills | Own processing, own brand “Molochnaya Radost” | Food retailers across Tajikistan and Kyrgyzstan | 2022 | http://afzal.tj/1.php |
| Amid Food | TJ Sughd | Meat processing | est. 1,500 cattle in partner feedlots | Own cropland and feed purchases | Processor sources from local network of feedlots | Own supermarkets in Khujand | 2024, 2025 | https://www.amid24.tj/ |
| Marmari / Avesto Group | TJ Khatlon | Cattle feed-lot | 3,500 cattle in four feedlots | 800 ha cropland, grazing | Own feed mill, own processing, own brand “Marmari” | Food retailers in Dushanbe | 2024 | https://avesto.tj/en/line-of-business/agriculture/ |

Source: Authors based on case study research.

Livestock herds on the enterprises surveyed in Table 4 typically include several thousands of animals, sometimes spread across several sites. Except for one, all have access to considerable cropland resources that allow them to grow their own fodder. Several reported that their cropland has irrigation equipment installed. The importance of grazing as a feeding strategy varies across the cases. All involve a high degree of vertical integration, typically running their own processing facilities, and often retail outlets. Some have established recognisable brands with brand stores in the cities. All predominantly serve their domestic markets, typically urban consumers in the closest urban centre (Almaty, Dushanbe, Khujand). Attempts at smallholder integration are rare, the feedlots usually run their own cow-calf operations on separate sites. Amid Food in Sughd (Tajikistan) is the only case where a processing company aims at vertical coordination with smaller, independent feedlots.

All of the enterprises keep animals with enhanced genetics and some imported live animals from abroad. Finance often comes from entrepreneurs active in other agricultural businesses (such as milling) or sectors (such as mining), and some companies seem to enjoy high-level political support, especially in Tajikistan. Many large livestock operations in Kazakhstan benefit from subsidies for genetic improvement, such as purchase of pedigree bulls. In our interviews, company managers repeatedly complained about the lack of qualified and motivated workers.

We thus observe the emergence of separate commercial value chains based on the vertical integration of animal feeding, production, processing and (often) retailing of milk and meat. The enterprises studied here use much more advanced technologies than the otherwise prevalent smallholders and they predominantly grow fodder on their own cropland. They engage in formalised market relations and typically supply higher quality products that are also earning a price premium, sometimes creating a market niche under exclusive product branding. While their market share is small at the moment (Figure 11), we should note that this is a dynamic market segment. On one hand, most enterprises listed in Table 4 have been operating for many years and display a certain degree of business stability. On the other, several have been developing new marketing strategies only recently, especially the promotion of own brands and outlets. For example, Amid Food opened its first own hypermarket store in Khujand just in 2022. Zhana Aktasty was supposed to establish its own processing plant in 2023. Marmari made its first greenfield investment in 2021.



Figure 12 Enterprise milking parlour near Almaty (left), cattle feedlot in Khatlon (right)

Source: Authors 2015 (left), Marmari promotional video 2024 (right).

8 Discussion

The evidence provided here suggests that the transformation of livestock value chains in Central Asia has progressed slowly. On the one hand, a precarious relation of animal numbers to fodder resources has prevented the intensification of livestock production among smallholders, while widespread informality and monopolisation of downstream links hamper their integration into value chains. On the other, a small parallel chain emerged that is governed by livestock enterprises with access to cropland and modern technologies, fully integrated from fodder production to their own retail stores or brands. We now discuss the reasons for the widespread lack of value chain transformation, the prospects for further development and the role of government policy in this process.

8.1 Reasons for lack of a value chain revolution at farm level

One way of summarising our findings is to say that demand shifts emerging from urban centres in Central Asia are not effectively triggering the kind of revolutionary changes along the agri-food value chain that are observed in other emerging economies. Why not?

First, the evidence presented here supports the notion that in many parts of Central Asia, development of livestock production based on pastureland alone is technically difficult and probably often unprofitable (as it is in similar places worldwide, Steinfeld et al. 2006, 510). This is due to severe winters combined with limited area of winter pastures (especially in the Tajik and Uzbek sites studied here), pasture degradation in the past and present as well as complex access and use rights described before (see also Robinson and Petrick 2021, 23-36). Whilst mobile grazing systems with the full range of seasonal pastures do exist and support apparently profitable meat-producing operations e.g. in some parts of Kazakhstan (Thissen 2024), outside these areas intensification through access to cropland is crucial for herd growth. Yet as a result of misconceived land tenure reforms and paralysed land markets this is a key bottleneck for Central Asian livestock producers (see e.g. Robinson and Petrick 2024).

Moreover, due to other strategic priorities of national governments, arable land allocated to fodder is still only a fraction of what it used to be at the time of national independence (Figure A 3).

Second, herd growth in Central Asia has mostly implied incremental additions of animals to small herds that are kept by rural household producers and relatively small individual farms (Figure 3). Such producers are notoriously difficult to integrate into value chains, as market transaction costs per output volume are high (Key and Runsten 1999; Reardon et al. 2009). These transaction costs include the cost of searching and screening of suppliers, measures to secure production standards and product quality, and the cost of enforcing the contract terms. Under the conditions studied here, the costs of integrating small producers into value chains for the processor will be substantial. We therefore see very little support to smallholders in terms of resource providing contracts.

Third, the prevailing informality of market relations curtails competition and inhibits the emergence of transparent exchange. Poor public governance of private property rights, contract enforcement and quality standards have been diagnosed as economy-wide problems in Central Asian countries (OECD 2018). In the livestock sector, these issues inhibit the degree of specialisation and differentiation into commercially linked stages such as observed in Western market economies (MacDonald 2018). The poor shape of animal identification systems and public veterinary services in Central Asia are also symptoms of this problem (Robinson and Petrick 2021, 59-60).

Fourth, a lack of capital investment in logistics and processing along the value chain inhibits technical upgrading, which may be due to shallow capital markets and informal entry barriers in the logistics and processing sectors (Naumov and Pugach 2019, 50). Some of our respondents conjectured that food retailers in Kyrgyzstan and Tajikistan are under the control of a small political and business elite. Access to finance was mentioned as a major barrier to farm development by our survey respondents in Kazakhstan and Kyrgyzstan.

Beyond domestic urban demand, export opportunities for livestock products have not provided effective incentives for value chain transformation so far. Based on microdata from Kyrgyzstan, Esenaliev (2023) found that farmers close to markets and transport infrastructure were more likely to participate in export activities, but benefitted no more than those selling on domestic markets, largely due to the absence of organised value chains. Poor trade policies and institutions exacerbate the landlocked situation of Central Asian countries (Pomfret 2016). Transport costs, limited financing options for traders and a lack of standard compliance on export markets have contributed to the hugely negative trade balance (Thomsen 2016; Robinson and Petrick 2021, 72-75). Agricultural trade relations between Kazakhstan and China remain fragile (Alff et al. 2023).

8.2 The stability of bifurcated livestock value chains

In our study regions, strongly increasing animal numbers coincide with a relative absence of formalised modern value chains. If livestock is kept to earn income, these two conditions are consistent only if the local sale of animal products still earns a sufficiently high price to generate a margin over the costs. Indeed, those local marketing options which are available provide a plausible explanation for the persistence and even expansion of the observed smallholder livestock systems in parallel with a highly commercialised, vertically integrated system represented by enterprises and large feedlots that is struggling to win market share.

Pallot and Nefedova (2007, 190-195) explained the persistence of post-Soviet smallholder systems in a Russian context and Petrick and Götz (2019) examined it econometrically for a sample of Russian and Kazakhstani dairy producers as follows:

“The most lucrative outlets for small producers ... are local food markets in the vicinity of urban agglomerations or along mainline roads and railways, where small quantities can be sold to second home owners and urban commuters. Dairy processors and other formal organisations are the least preferred customers, as they pay the lowest prices and quality standards may be higher. Milk trade by informal intermediaries who pick up the milk at the farm gate ranges somewhere in between” (Petrick and Götz 2019, 18).

As the market for direct sales has a natural limit represented by the number of local consumers, the number of animals supported by a (primarily) local marketing systems is constrained by the size (or growth) of the local population.

All sites studied here provide evidence of bifurcated value chains in dairy and beef, where low-cost smallholder producers for small local markets prevail over the integration into more demanding modern value chains (see e.g. Figure 10). Note that the margins in these smallholder systems depend on low (opportunity) cost of family labour and the use of environmental resources that are accessible for free or at very low cost, such as public grazing land and local water sources.

At the same time, large livestock enterprises are constrained by high costs of hired labour, trade and logistics as well as contract enforcement and quality control. It is reasonable to assume that procurement from primary producers, contracting and processing exhibit increasing economies of scale. For example, the costs per unit of dairy output from milk collection by dairy tankers, the management of milk and meat quality, and enhanced processing, would all decrease under larger production units. At the moment, processors across Central Asia report underutilised capacities. It is then possible to imagine an alternative scenario of predominantly modern, integrated value chains that produce at lower cost than the smallholders but only if most of the smallholders disappear and production is concentrated in large enterprises and feedlots.⁴ We end up with a livestock economy exhibiting two equilibria. The possibly more efficient one cannot be reached due to the self-stabilising nature of smallholder animal husbandry and the lack of coordination towards a lower cost equilibrium dominated by integrated large-scale producers. Escaping the smallholder trap would require a coordinated action of shifting all animals into corporate farms that yield economies of scale, a “big push” (see Krugman 1993; Ray 1998, 131-161).

Our claim of a dual equilibrium thus provides an additional explanation for the absence of livestock value chain transformations in post-Soviet settings. In the light of economically doomed and morally questionable collectivisation drives in the past, forced consolidation seems unlikely today (although Uzbekistan has experimented with such policies: Petrick and Djanibekov 2019; Babadjanov and Petrick 2023). But our diagnosis raises questions about the most promising strategy for sector modernisation, if we take this as the desired policy goal of most agricultural strategy documents issued by Central Asian governments over the past decade.

⁴ The external costs of carbon emissions would also decline under a production regime of large-scale enterprises and feedlots (Pelletier et al. 2010).

8.3 Modernisation strategies: including or bypassing smallholders?

What then is the right strategy for livestock value chain development in Central Asia? Barrett et al. (2022, 1351) note that commercial inclusion of smallholders to raise living standards has been a chief aspiration of many modernisation attempts worldwide. While this abstract goal will find many supporters in Central Asia as well, debates about the appropriateness of small or large farms for post-Soviet agriculture have been controversial. A recent “Southernisation” of Central Asian agriculture, i.e. the almost complete shift to economically precarious smallholder farming after de-collectivisation, makes clear that regardless of political preferences for one or the other farming model, the challenges are similar to those of other Asian and African emerging economies dominated by small farms (Petrick 2021).

European and Asian comparator countries exhibit varying experiences. Dries et al. (2009) show that small farms in Albania, Bulgaria and Poland received valuable support from cooperatives and commercial processors, partly backed by Western investors, in the course of economic transition in the late 1990s and early 2000s. Huang et al.’s (2012) study of milk marketing in Greater Beijing during the early 2000s underlines the role of competition, the entry of private value chain intermediaries and the establishment of private milk collection stations for keeping the dairy chain viable for smallholders in China. Yet in the case of Punjab in India, Burkitbayeva et al. (2020) note that vertical coordination played at best a minor role in the transformation of traditional dairy farming systems. At the same time, they observed the parallel emergence of highly integrated dairy enterprises driven by commercial investors and equipped with modern technologies and genetics, similar to the situation described above in our study sites.

In our surveys, over 70% of respondents sold at least one animal or livestock product in the reporting period (except in Kazakhstan, where the numbers are lower). These findings are similar to those in post-socialist countries from the early 2000s, which found that the proportion of farms and households selling produce ranged from 60-80% (Lerman 2004, 463). However, many sell small volumes and even in our peri-urban settings around 30% keep livestock solely for self-consumption or other reasons, such as storage of wealth. Our data also suggests that strategies targeting the integration of small livestock producers into value chains have mostly failed. This applies both to the establishment of agricultural cooperatives as well as contract farming models. Are there other ways that livestock business models could become more inclusive to smallholders in Central Asia?

Central Asian governments have experimented with state-led consolidation of cotton (and other) farmers into “clusters”. Yet the available evidence shows that these entities have constrained farmers’ choices even further than before, without improving their economic benefits (Babadjanov and Petrick 2023; Petrick et al. 2017).

Given the discouraging record of grassroots or producer-driven models in Central Asia and the high costs of backward integration and contracting for processors, perhaps more attention should be paid to the middlemen, traders and brokers. Vorley et al. (2009) present examples of commercial intermediaries in India that add service and input provision for farmers to their rural retail operations. In another case, a producer organisation in the Philippines created a service and marketing unit as part of their business portfolio. In our study, the regional meat processor Amid in Sughd (Tajikistan, Table 4) provides a rare case of integrating smaller, independent producers into an overarching business model of quality meat distribution and retailing. It should be studied further.

Another little studied pathway of sector upgrading within heterogeneous agricultural structures is through spillovers from large- or medium-scale to smaller farms. Fodder and input supply by the former collective farms to rural households was practiced during the Soviet Union and was still observable in Kazakhstan in the early 2000s (Petrick et al. 2014). Recent evidence from Africa suggests that smallholders can benefit from the emergence of medium-scale farmers, as they bring commercial buyers, mechanisation rental, input and service access, and ultimately rising wage levels to rural communities (Jayne et al. 2019). Lampe and Sharp (2018) provide a fascinating account of how elite farmers triggered the modernisation of smallholder dairy systems in Denmark. We need to ask who are the middle farmers in Central Asia? Can they contribute to the overall transformation of the smallholder sector? Our findings in Table 2 raise some doubts that individual farmers are performing better than households. Is there any evidence of spillovers that may be more subtle than the classical dependency on the collective farms?

In our study, the dairy sector in Chui (Kyrgyzstan) comes closest to a smallholder-friendly sector development model. Across our sites, this one exhibits the most favourable natural conditions and largest cropland reserves, it has direct access to a large consumer market in Bishkek and benefitted from repeated waves of donor support in technology upgrading. Compared to the other cases we studied, a more liberal land market led to enhanced land access for farmers who doubled the area of fodder grown on cropland within 20 years (Figures A3 & A4). Livestock owners provide the most intensive fodder rations across all samples; they are more active on rural financial markets; also thanks to donor activities, cooling technology and artificial insemination can be found more widely; and dairy in Chui represents the longest value chain in our study. Yet, as Figure 9 illustrates, progress has been stepwise and partial even here.

In several of our sites, there are signs that vertically integrated livestock operations gain a foothold in urban high-value markets (Table 4). In light of the recent dynamism of enterprises and feedlots described above, we claim that livestock revolutions in Central Asia are more likely to happen in enterprises than among smallholders. Does the recent emergence of livestock enterprises have the potential to break up the self-stabilising smallholder equilibrium described before? Clearly more research and monitoring are required to answer this question.

8.4 The role of government policies in value chain upgrading

Livestock support policies in Central Asia rarely reach the type of farmers where the most animals are, i.e. the smallholders. Government-directed aggregation of producers into larger units such as clusters or cooperatives largely failed, whereas most government support measures aiming at individual farm entities seem to overlook the household producers. Our research provides evidence that the widely used credit subsidies mostly end up with a few large farmers, as smaller ones don't apply in the first place due to a lack of profitability and high risks. Land reform policies led to slow and conflicting changes, as land markets in all countries except Kyrgyzstan remain highly constrained beyond occasional waves of government-mandated cropland allocation. Pastoral tenure reforms have been protracted, partly erratic and rarely led to arrangements that combine flexibility with the access security that pastoralists demand (Robinson and Petrick 2021, 11-36).

Interventionist policies have lacked consistency and coordination. Recent years have seen the proliferation of wasteful import-substitution attempts among Central Asian governments that ushered in a subsidy race for setting up domestic and potentially export-oriented beef and dairy chains. In 2019,

both Kazakhstan and Uzbekistan introduced support programmes for the import of breeding stock, partly supported by international donors. The resulting demand for cattle in Uzbekistan elevated prices well above those in Kazakhstan, which created strong incentives for the re-export of animals from the latter. Traders in Kazakhstan first imported animals under the domestic subsidy programme, then exported them to Uzbekistan to receive the much higher market price there, with rising meat prices in Kazakhstan. In January 2020, the Kazakhstani government thus introduced an export ban on live cattle. In turn, cattle exports from Kyrgyzstan to Uzbekistan skyrocketed, leading to an export ban there in November 2020. All governments have attempted to increase the capacity of their domestic processing capacities for export, but none of their neighbours is keen on importing processed meat. Kazakhstan extended the export ban to August 2024. After the end of the ban, complications with electronic export permits created headaches among the few traditional exporters of live cattle to Uzbekistan (EIDala.kz 2024). Such policies create a highly unpredictable investment climate for livestock producers and do little to promote mutually beneficial trade.

In terms of stimulating the emergence of modern livestock value chains, government policy in Central Asia has been a fairly frustrating exercise for both policymakers not achieving their declared goals and many value chain actors experiencing ineffective policies. This discussion section has highlighted many of the dilemmas and potential levers for action. While there are no globally available blueprints, reform packages recommended by international advisors include the redirection of subsidies towards the improvement of rural public services and local governance institutions, agricultural credit and insurance reform, and the liberalisation of land markets and cross-border trade, to stimulate an endogenous restructuring of the chain (Lerman 2004; OECD 2018; Petrick et al. 2018).

9 Conclusions

A livestock value chain revolution has not yet taken off in Central Asia. Livestock intensification is progressing only slowly, as the bulk of animals continue to be kept by small household producers often dependent on a deficient fodder base. Supermarkets have gained market shares in the cities, but integrated high-value chains have emerged only slowly. Contracting and vertical coordination remain limited, often based on informal intermediation by traders, and product quality levels are wanting with standards only partially established and enforced by local processors. Low cost forage and labour coupled with sufficiently lucrative but quantity-constrained local sales channels favour the persistence of smallholder farming systems that so far have withstood competition for resources and market shares by vertically integrated livestock enterprises.

In this sense Central Asia differs from many emerging economies whose agri-food transformations are documented in the literature (Barrett et al. 2022). Given the manifold structural causes for the persistence of smallholder livestock husbandry in Central Asia that we discussed above, it is unlikely that the situation is going to change soon. When, at the turn of the millennium, liberalisation of retail and processing triggered a sweeping “supermarket revolution” in many (hitherto) developing countries (Reardon et al. 2009), the Central Asian agri-food sectors had not yet bottomed out from their post-Soviet collapse (Petrick 2021). Structural transformation is still lagging behind today.

This does not mean that livestock is a stagnating sector in Central Asia. In fact, animal numbers have proliferated in most countries. Worryingly though, along with rural population growth, we witness the

multiplication of a farming model that in many places is already overstressing the use of natural resources like pastures and water. Moreover, its produce stemming from extensive ruminant husbandry leaves a heavy carbon footprint (Robinson and Petrick 2021).

In contrast to other countries, intensification and commercialisation of livestock value chains do promise a solution to many of the trade-offs inherent in traditional systems in Central Asia (Wilkes and Merger 2014). Improved husbandry, herd management practices and animal growth all promote climate and environmental goals, and favour income opportunities in modern fattening and dairy enterprises. Where high-income countries are struggling with the heavy environmental impact of industrialised livestock production (MacDonald 2018), we see potential in Central Asia that corporate business models will lessen the trade-offs between securing rural livelihoods, economic growth, sustainable land use and mitigating climate change (i.e. the Sustainable Development Goals 1, 2, 8, 13 and 15; Robinson and Petrick 2021). If employment opportunities outside the agricultural sector continue to grow, corporate farms may create win-win scenarios for agri-food value chain transformations in Central Asia. At the same time, provision of public goods supporting middle sized family farms to develop, as well as investing further into inclusive models of small farmer integration will soften some of the adjustment frictions that may emerge from structural change in agriculture.

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Appendices

A1. Survey sampling

Almaty (Kazakhstan): Surveyed households and farms were selected through a two-stage sampling process, with first sub-district, then farmers and households sampled at random using different methods. Firstly, lists of peasant farms (*kristianskoe khozaistvo*) covering the districts of interest were obtained. Fifteen clusters of 13-14 farms were selected over the list of sub-districts using probability according to size based on farm numbers from the list. Two sub-districts were very large and so were represented by two clusters – i.e. 26 farms, reducing the final number of selected sub-districts to 13. The 13-14 farms in each cluster were selected at random from the lists, to bring the total to 200, each with an equal probability of selection. Concerning households, lists were not available so these were selected by visiting three or four houses at random in each cluster to bring the total number of sampled households to 50. In the field, as many of the livestock-owning farms in Enbekshikazakh district could not be found, more than the original selected sample of two sub-districts had to be sampled. Thus, a total of 16 sub-districts appear in the final sample, five in Enbekshikazakh and eleven in Raiymbek district.

Chui (Kyrgyzstan): the three selected districts include five to twelve sub-districts each. Lists of all households and farms having cattle in each of these sub-districts were compiled from pasture committees, veterinary services or village authorities. The four sub-districts in each district having the most cattle were selected and only those households/farms having a minimum of five cattle per household were included in the sample frame. The sample was stratified by district to give the same number of respondents - around 83 - in each. The fraction of the sample frame (and probability of being selected) is thus different in each district. In each of the four selected sub-districts in each district, a constant fraction of households was sampled. There was no stratification by household and farm. In reality, the difference between farmers and households is slight and the two groups represent a continuum rather than quantitatively different categories. In the final sample the proportion of self-declared households and farmers turned out to be around 50:50.

Kashkadarya (Uzbekistan): Lists were compiled of all households (*dekhan*) in the two districts (comprised of 63 sub-districts). At the district level households were selected to ensure that there was no more than 100 and not less than 50 households per district: $50 < \# < 100$. At the sub-district level, using the lists, every sixth household was selected up to a total of ten in each sub-district. This resulted in a random sample in which no more than ten households were sampled per sub-district. Thus, smaller sub-districts are over-sampled and the sample is neither a constant proportion nor a constant number per sub-district. Farmers (*fermer*) were represented by two types: those having over 30 animals are 'livestock farms' whilst those having 1-30 head of cattle belong to the 'mixed farm' category. These two farm types were selected from lists obtained from district authorities. Respondents were picked from each list separately, to give a 50:50 split between the livestock and mixed farm category. Concerning the split between districts, not more than 50 and not less than 25 respondents: $25 < \# < 50$ were selected per farm category in each district. Over the two districts there were a total of 400 livestock farmers on the list. A total of 79 of these were randomly selected out of the entire list, with no stratification for sub-districts. There was a very large number of mixed farmers. The 78 to be sampled were

randomly selected across the lists, again with no stratification for sub-districts. Thus, farms with livestock specialization are over-sampled. Questionnaires eventually usable for analysis came to 152 households, 73 mixed farms and 76 livestock farms.

Sughd (Tajikistan): Interviewees in the chosen districts were selected through a two-stage sampling process. In the first stage sub-districts (jamoats) were randomly selected in each district and households/farmers in each selected jamoat (usually consisting of a number of villages) were selected via list of telephone numbers and using the “snowball” method. Cattle ownership was also a key criteria, with households and farms selected to own a minimum of 2 cattle. Overall, 154 farmers and 148 households were sampled across 23 jamoats.

A2. Generation of geographical data

Raster data were obtained using Google Earth Engine and values extracted at points corresponding to the GPS coordinate of the interview, or (where this was lacking) from the coordinates of the interviewees’ home village (Table A 1). Distance from the nearest large city (Almaty, Bishkek, Khujand) was measured as the crow flies from location of village/interview using GIS software in R. Data for altitude were extracted from the Shuttle Radar Topography Mission (SRTM) digital elevation model. Population density was measured at the sub-district level and taken from official statistics in each country. These data were not generated for the Uzbek sample, as GPS coordinates and population statistics were unavailable.

A3. Supplementary tables

Table A 1 Geography and specialization of sampled farms and households

| Variable | Almaty | Chui | Sughd |
|---|--------|------|-------|
| Mean | | | |
| Distance from nearest national or regional capital city, km | 205 | 61 | 38 |
| Altitude, masl | 1590 | 855 | 707 |
| Population of sub-district | 6255 | 9812 | 28145 |

Note: No information available for Kashkadarya.
Source: Authors based on sources quoted in text.

Table A 2 Barriers to accessing land

| Response | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|---|-------|------|-------|------|-------|--------|-------|-------|------|
| Respondents wishing to acquire more cropland (% of subsample) | 62 | 63 | 72 | 57 | 59 | 53 | 33 | 66 | 79 |
| Mentioning the following specific problems with acquisition (% of subsample): | | | | | | | | | |
| Land unavailable | 38 | 38 | 20 | 21 | 34 | 36 | 16 | 30 | 34 |
| Lack of finance | 24 | 28 | 30 | 16 | 18 | 0 | 0 | 19 | 22 |
| Complex transaction process | 26 | 24 | 3 | 2 | 18 | 29 | 8 | 5 | 5 |
| Expensive transaction process | 14 | 12 | 2 | 0 | 20 | 3 | 0 | 8 | 19 |
| Cannot afford tools or inputs | 18 | 15 | 5 | 2 | 7 | 0 | 0 | 2 | 1 |
| No irrigation water | 18 | 20 | 3 | 6 | 17 | 21 | 14 | 6 | 13 |
| Lack of good land | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| Land located far from residence | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Mentioned one or more of the above problems | 62 | 63 | 66 | 49 | 62 | 51 | 27 | 36 | 44 |

Source: Authors based on survey data.

Table A 3 Frequency of roughage and concentrate provision

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|---------------------------------------|-------|------|-------|------|-------|--------|-------|-------|------|
| Percentage of subsample: | | | | | | | | | |
| Self produced roughage | 56 | 85 | 28 | 68 | 68 | 93 | 93 | 45 | 73 |
| Purchased roughage | 72 | 42 | 90 | 55 | 86 | 26 | 45 | 50 | 31 |
| Self produced concentrate | 10 | 25 | 34 | 66 | 7 | 58 | 37 | 7 | 27 |
| Purchased concentrate | 76 | 68 | 72 | 46 | 91 | 79 | 92 | 72 | 71 |
| Insufficient fodder | 58 | 48 | 30 | 17 | 57 | 34 | 33 | 22 | 18 |
| Keeps stall-fed cattle all year round | 2 | 2 | 77 | 69 | 20 | 64 | 32 | 0 | 0 |

Source: Authors based on survey data.

Table A 4 Type of fodder provided

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|------------------------------------|-------|------|-------|------|-------|--------|-------|-------|------|
| Percentage of subsample providing: | | | | | | | | | |
| Natural hay | 88 | 80 | 39 | 22 | 20 | 25 | 3 | 58 | 74 |
| Cultivated hay | 32 | 59 | 69 | 82 | 75 | 89 | 67 | 28 | 32 |
| Silage | 6 | 4 | 3 | 4 | 45 | 55 | 12 | 26 | 31 |
| Grain or combined feed | 84 | 89 | 92 | 95 | 90 | 93 | 92 | 66 | 73 |
| Crop residue | 2 | 3 | 26 | 23 | 60 | 79 | 68 | 4 | 6 |
| Root crops | 0 | 0 | 2 | 4 | 3 | 1 | 1 | 24 | 31 |
| Vegetables | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Other fodder types | 0 | 2 | 0 | 0 | 5 | 3 | 5 | 0 | 6 |

Source: Authors based on survey data.

Table A 5 Frequency and volume of cattle consumption, sales and purchase

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|---|-------|------|-------|------|-------|--------|-------|-------|------|
| Mean over last 12 months, head: | | | | | | | | | |
| Cattle owned | 8.7 | 32.5 | 11.3 | 17.6 | 4.9 | 49.3 | 9.0 | 5.2 | 17.9 |
| Cattle slaughtered | 0.5 | 0.9 | 0.1 | 0.1 | 0.1 | 0.3 | 0.2 | 0.2 | 0.5 |
| Cattle sold | 1.0 | 5.0 | 3.3 | 6.5 | 1.5 | 6.5 | 2.8 | 1.1 | 1.4 |
| Percent of respondents, last 12 months: | | | | | | | | | |
| Slaughtered any cattle | 42.0 | 51.0 | 8.4 | 5.3 | 7.2 | 18.4 | 9.6 | 12.8 | 27.9 |
| Sold any cattle | 44.0 | 52.0 | 68.9 | 71.8 | 52.0 | 77.6 | 56.2 | 39.2 | 56.5 |
| Purchased any cattle | 6.0 | 14.5 | 26.1 | 42.7 | 11.8 | 32.9 | 9.6 | 27.0 | 45.5 |

Source: Authors based on survey data.

Table A 6 Frequency and volume of sheep consumption, sales and purchase

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|---|-------|------|-------|------|-------|--------|-------|-------|------|
| Mean over last 12 months, head: | | | | | | | | | |
| Sheep owned | 17 | 124 | 11 | 38 | 4 | 55 | 10 | 6 | 9 |
| Sheep slaughtered | 5 | 8 | 2 | 5 | 1 | 6 | 1 | 0 | 1 |
| Sheep sold | 7 | 14 | 2 | 7 | 2 | 11 | 2 | 1 | 2 |
| Percent of respondents, last 12 months: | | | | | | | | | |
| Slaughtered any sheep | 66 | 84 | 42 | 63 | 37 | 83 | 44 | 22 | 33 |
| Sold any sheep | 12 | 32 | 18 | 37 | 26 | 66 | 26 | 11 | 27 |

Source: Authors based on survey data.

Table A 7 Channels for beef sales

| Variable | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|-------------------------------|-------|------|-------|------|-------|--------|-------|-------|------|
| N Sold beef in last 12 months | 5 | 22 | 2 | 5 | 48 | 51 | 27 | 15 | 26 |
| Percentage selling to: | | | | | | | | | |
| District market | 0 | 32 | 0 | 40 | 55 | 26 | 38 | 47 | 46 |
| Provincial market | 40 | 14 | 0 | 0 | 2 | 8 | 4 | 0 | 0 |
| Neighbours | 20 | 9 | 0 | 20 | 2 | 0 | 4 | 0 | 0 |
| Traders | 40 | 45 | 100 | 40 | 36 | 40 | 42 | 0 | 4 |
| Agro-processing company | 0 | 0 | 0 | 0 | 2 | 16 | 12 | 0 | 0 |
| Market in other country | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| State purchaser | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| Butcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 50 |
| Other | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 13 | 0 |

Source: Authors based on survey data.

Table A 8 Barriers to farm development

| Response | KZ-HH | KZ-F | KG-HH | KG-F | UZ-HH | UZ-LSF | UZ-MF | TJ-HH | TJ-F |
|--------------------------------|-------|------|-------|------|-------|--------|-------|-------|------|
| Percentage of subsample: | | | | | | | | | |
| Pasture land | 36 | 34 | 52 | 31 | 47 | 20 | 29 | 51 | 51 |
| Pasture Infrastructure | 2 | 4 | 28 | 17 | 7 | 8 | 5 | 3 | 5 |
| Water supply in pasture | 10 | 10 | 5 | 4 | 18 | 17 | 18 | 22 | 23 |
| Land for growing fodder | 36 | 18 | 37 | 17 | 76 | 74 | 79 | 38 | 36 |
| Other fodder issues | 12 | 14 | 11 | 10 | 65 | 75 | 85 | 20 | 12 |
| Labour | 6 | 9 | 10 | 7 | 2 | 5 | 3 | 3 | 3 |
| Finance | 28 | 27 | 34 | 47 | 4 | 3 | 4 | 18 | 18 |
| Market access | 6 | 12 | 15 | 8 | 0 | 0 | 0 | 1 | 2 |
| Animal health | 4 | 2 | 24 | 12 | 0 | 1 | 0 | 3 | 3 |
| Processing | 4 | 6 | 13 | 8 | 1 | 4 | 4 | 3 | 5 |
| Mentioned one or more barriers | 64 | 63 | 89 | 80 | 95 | 97 | 100 | 76 | 80 |

Source: Authors based on survey data.

A4. Supplementary figures

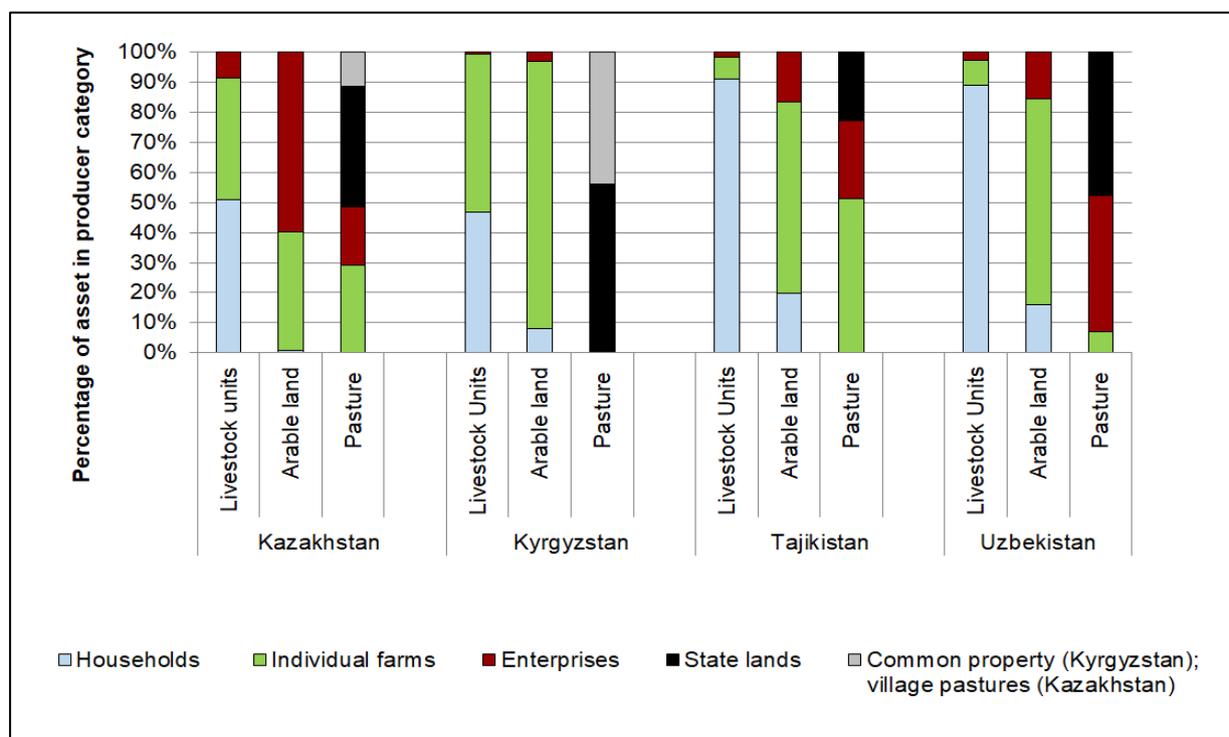


Figure A 1 Distribution of livestock and land by farm type in four Central Asian countries

Notes: In all countries, state reserve refers to unallocated state lands; forest land refers to pastures managed by the forestry department other pastures (such as national parks) are not included. Kazakhstan: Households may use common pasture owned by rural municipalities. In Tajikistan areas allocated to municipalities or leased by pasture users associations (which may include households) exist, but are unavailable in statistics. Source: Livestock: units calculated from raw national livestock statistics for 2022 using Eurostat (2020). Arable area: National statistics 2022 all countries. Pasture area: Kazakhstan: national statistics 2021 (but enterprises and farms were aggregated in those statistics so proportional split is taken from the year 2014); Tajikistan: national statistics 2022; Uzbekistan figures for 2017 from Naumov and Pugach (2019) citing Narbaev (2018).

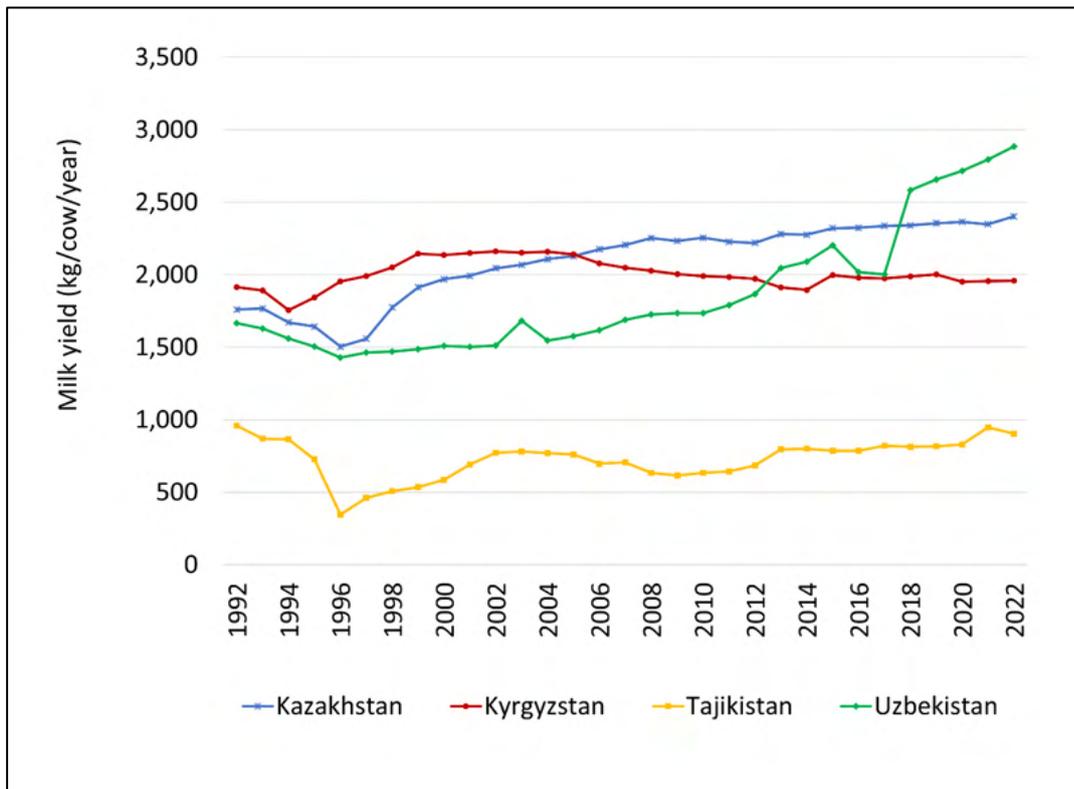


Figure A 2 National average milk yields in four Central Asian countries, 1992-2022

Source: FAOSTAT.

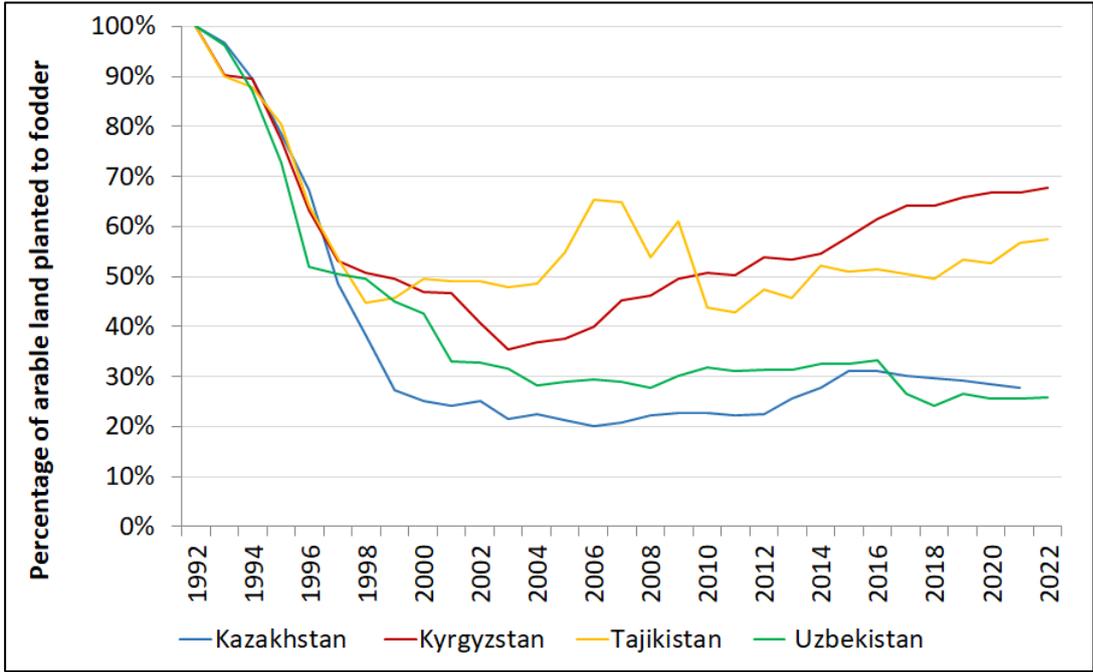


Figure A 3 Change over time of area planted to fodder (% of area planted to fodder in 1992)

Source: National Statistical Offices.
Note: Fodder statistics include perennial and annual hays, and maize but exclude other cereals.

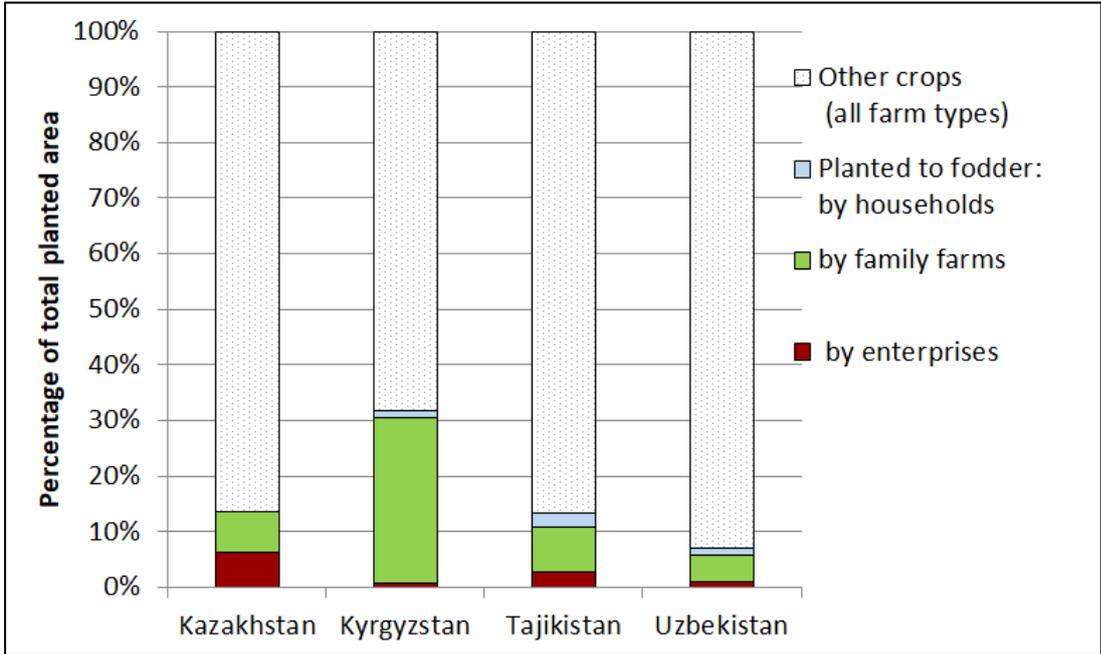


Figure A 4 Area planted to fodder by farm type (% of total area planted to crops)

Source: National Statistical Offices.
Note: Fodder statistics include perennial and annual hays, and maize but exclude other cereals. Data for 2021 (KZ), 2022 (KG, TJ), 2023 (UZ).

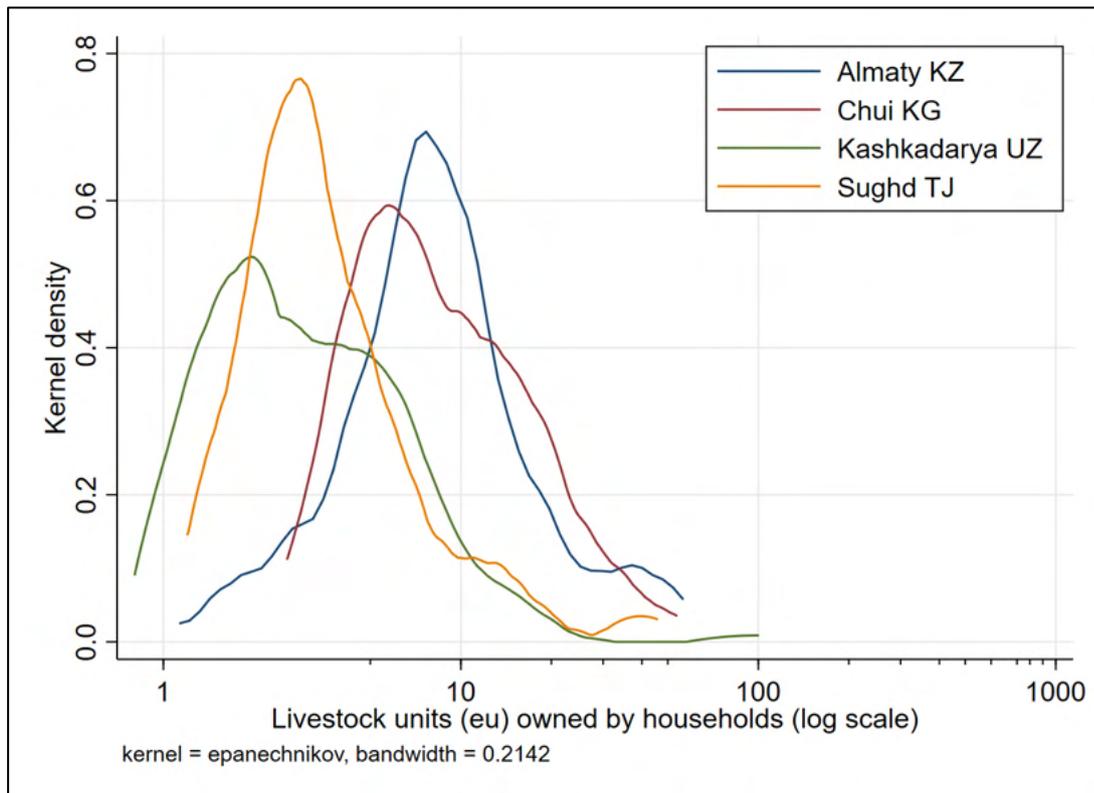


Figure A 5 Herd size distribution in households surveyed

Source: Authors based on ANICANET surveys.

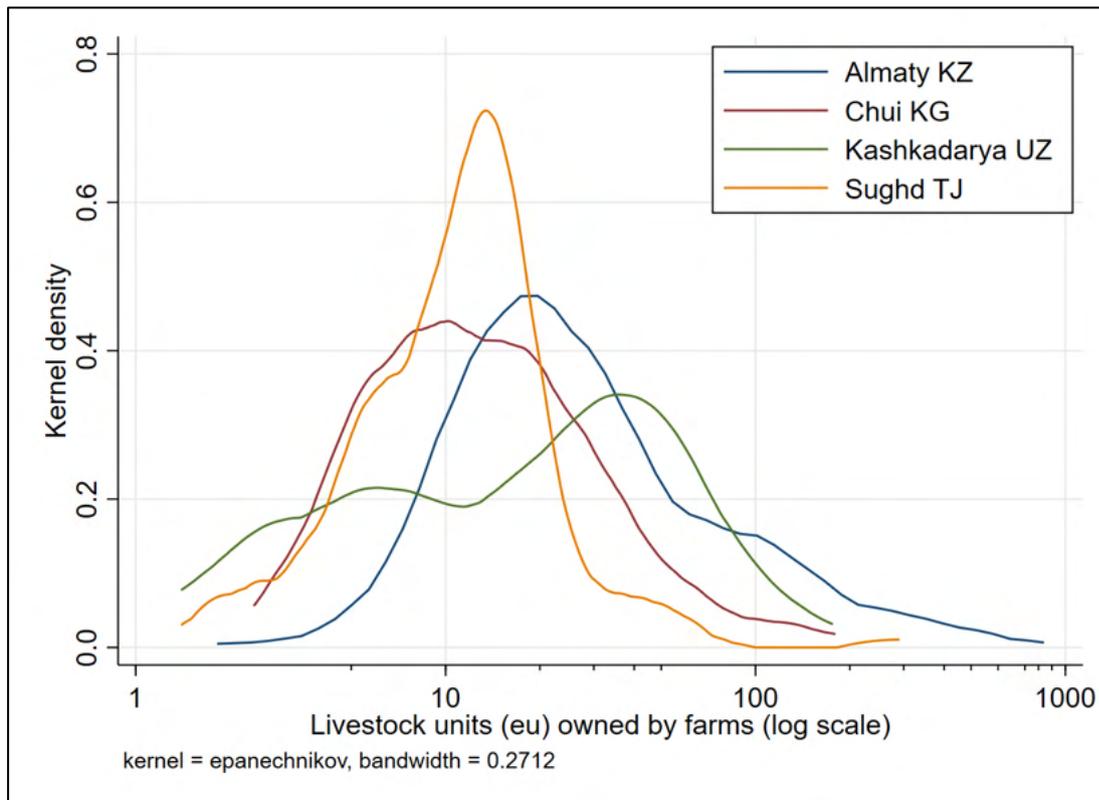


Figure A 6 Herd size distribution in individual farms surveyed

Source: Authors based on ANICANET surveys.

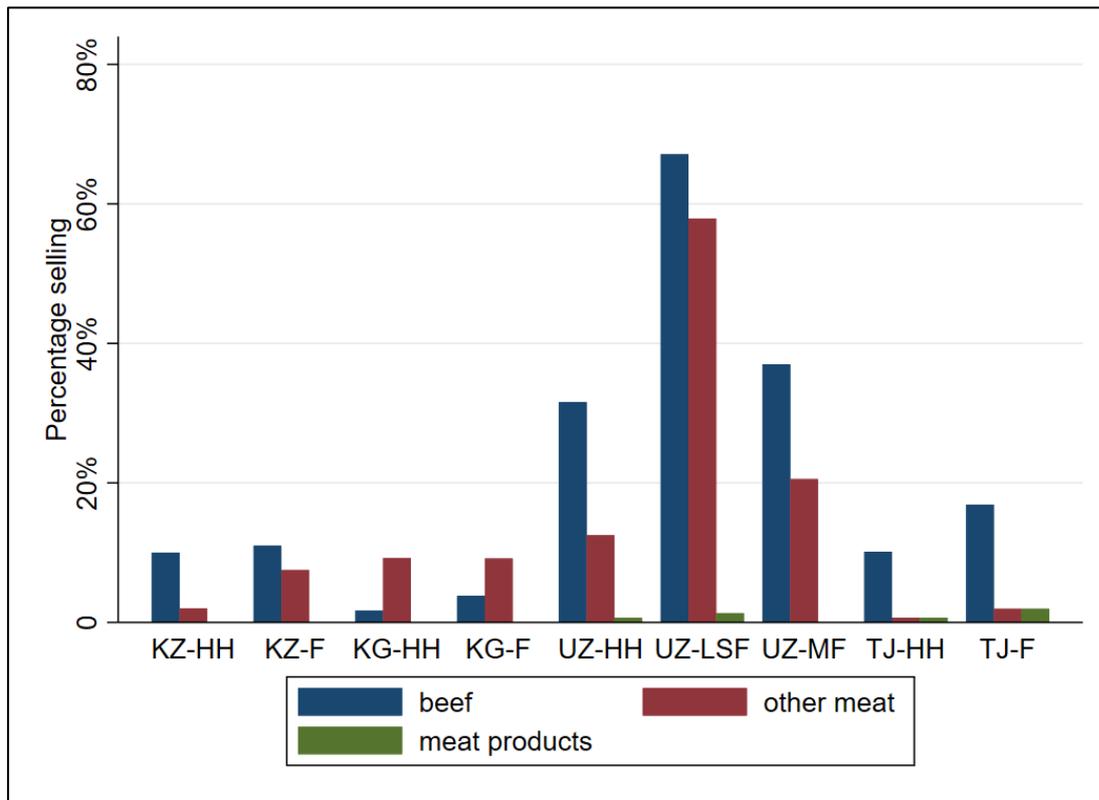


Figure A 7 Frequency of meat sales by farm type

Source: Authors based on survey data.

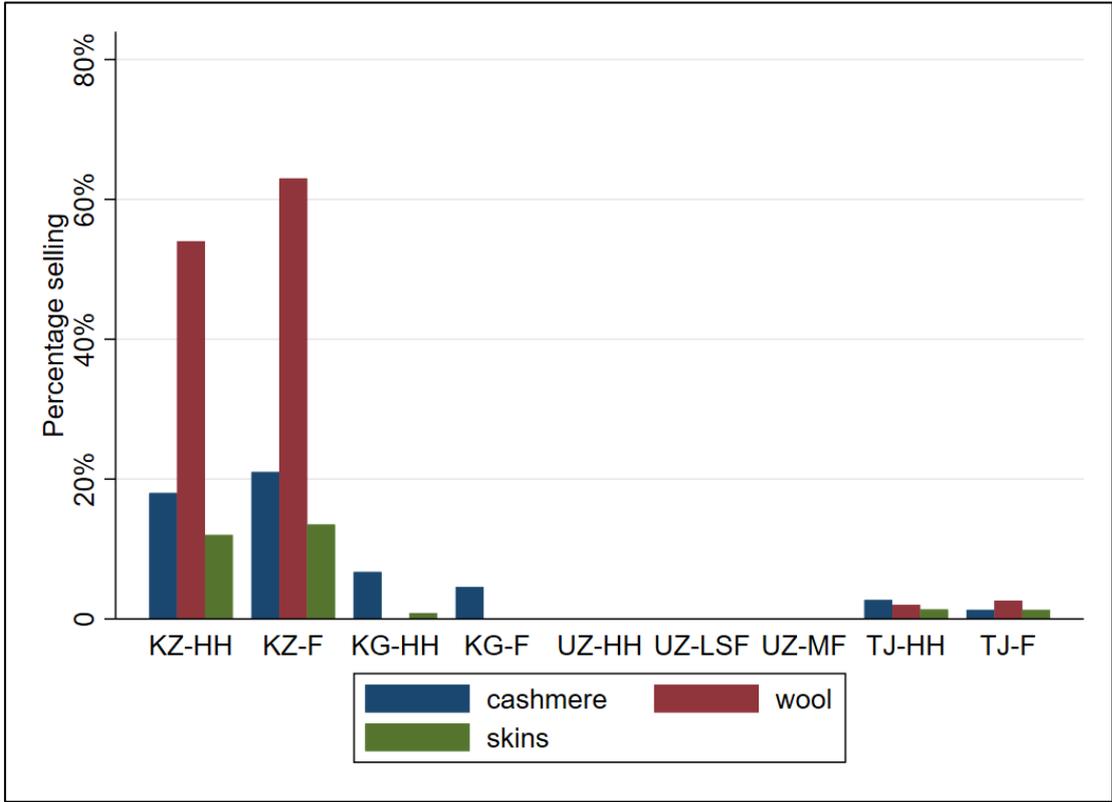


Figure A 8 Sales frequency of fibres and skins by farm type
Source: Authors based on survey data.

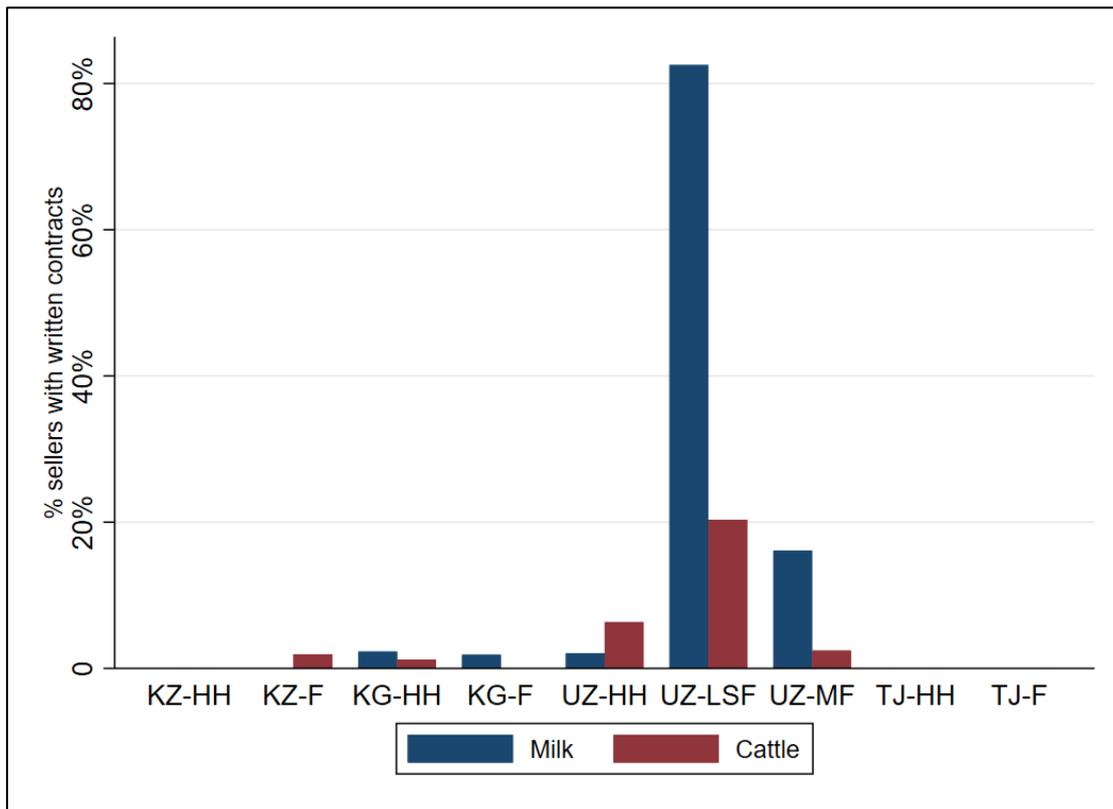


Figure A 9 Prevalence of formal marketing contracts: milk and cattle

Source: Authors based on survey data.

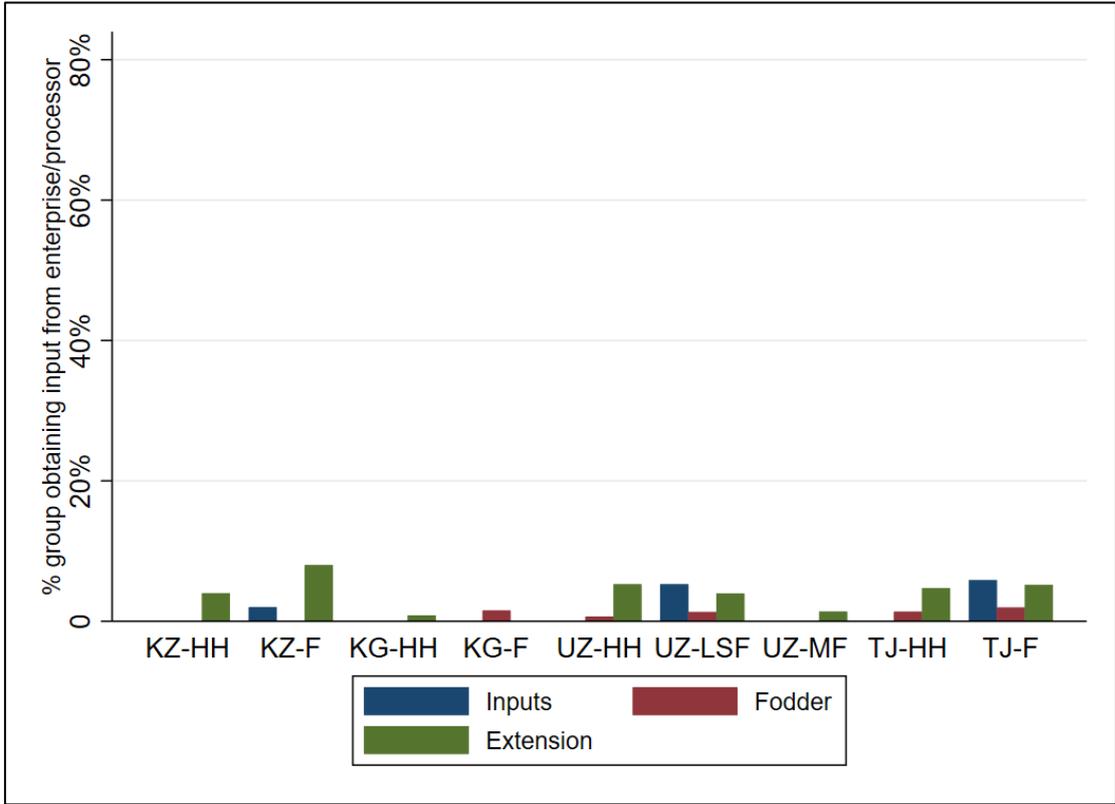


Figure A 10 Prevalence of inputs and service provision by purchasers
Source: Authors based on survey data.

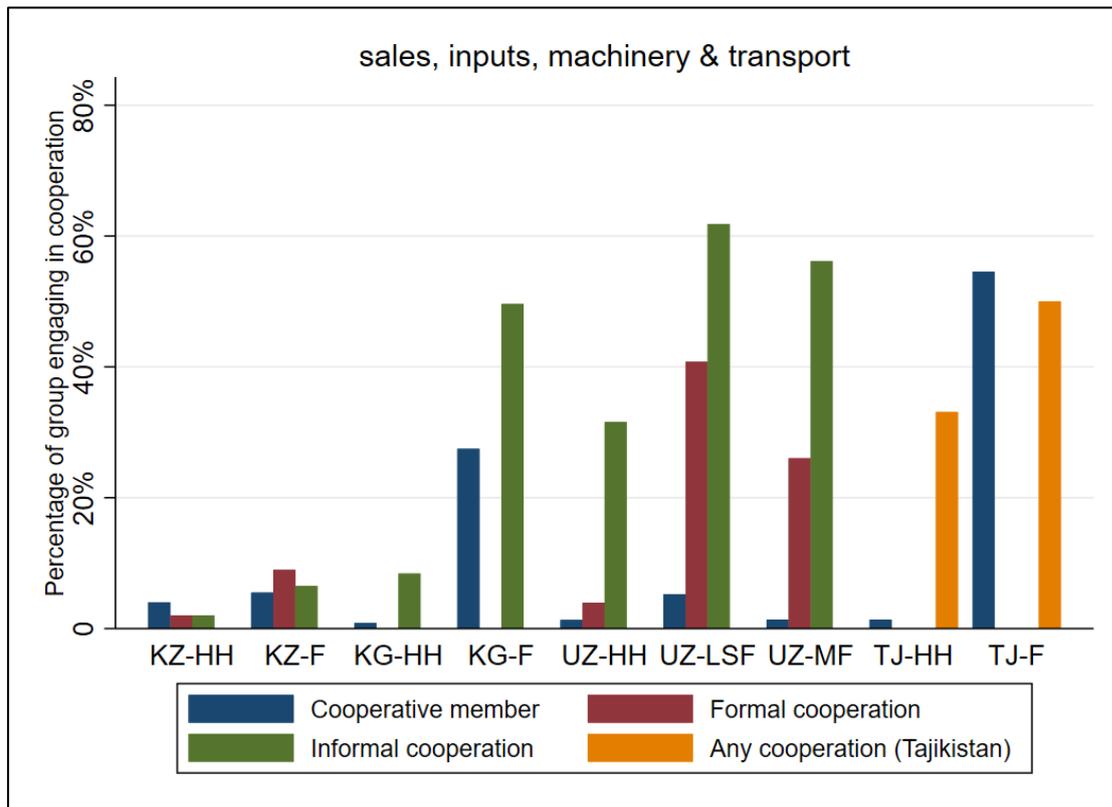


Figure A 11 Cooperative membership and cooperation

Source: Authors based on survey data.

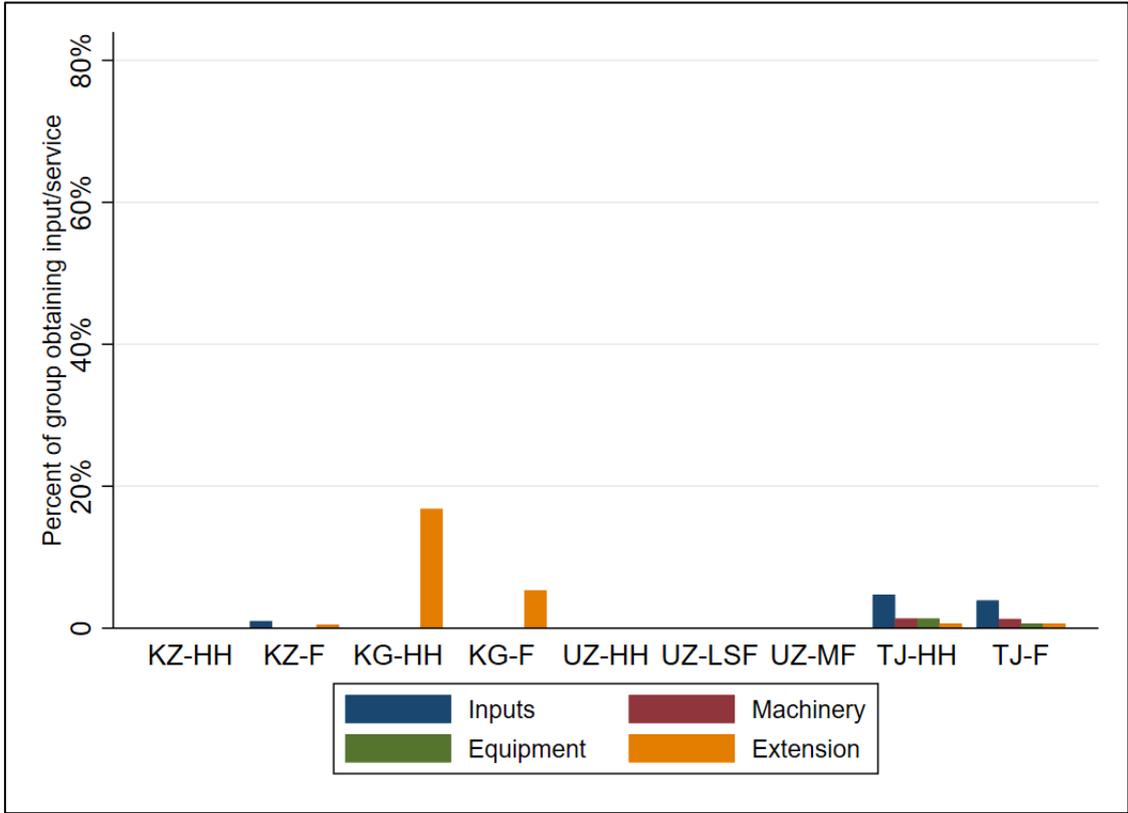


Figure A 12 Input and service provision by cooperatives

Source: Authors based on survey data.

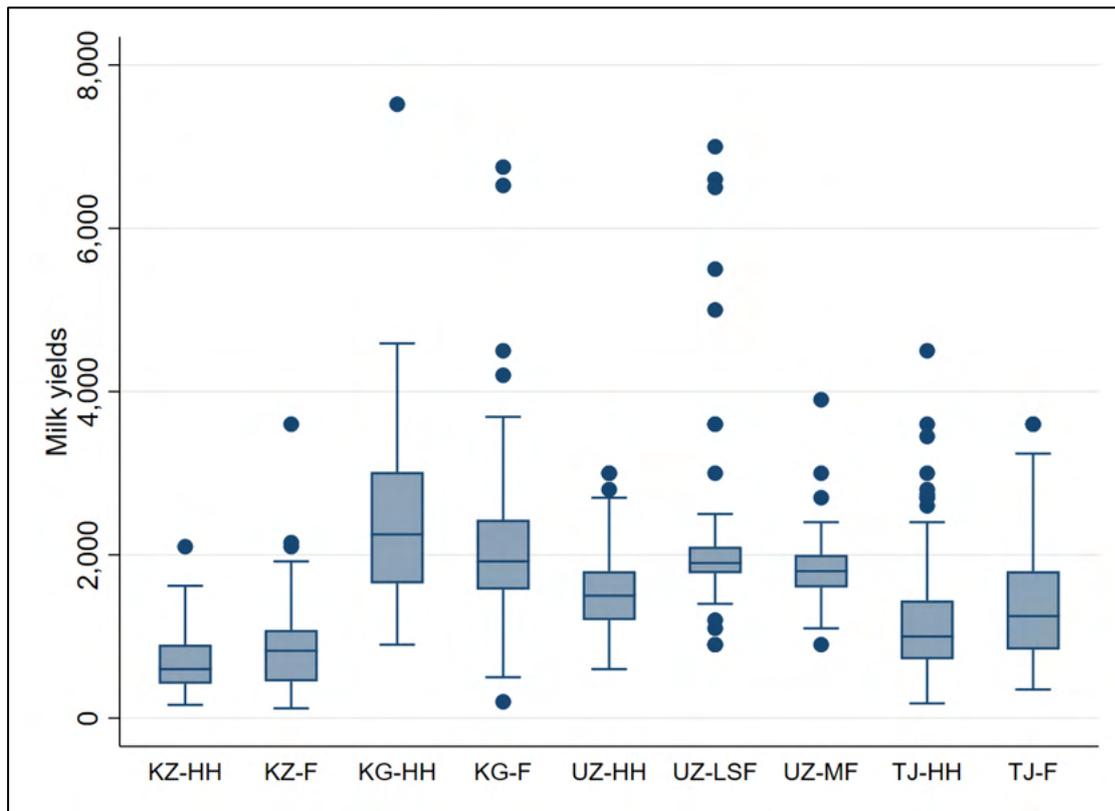


Figure A 13 Milk yields by subsample

Source: Authors based on survey data.

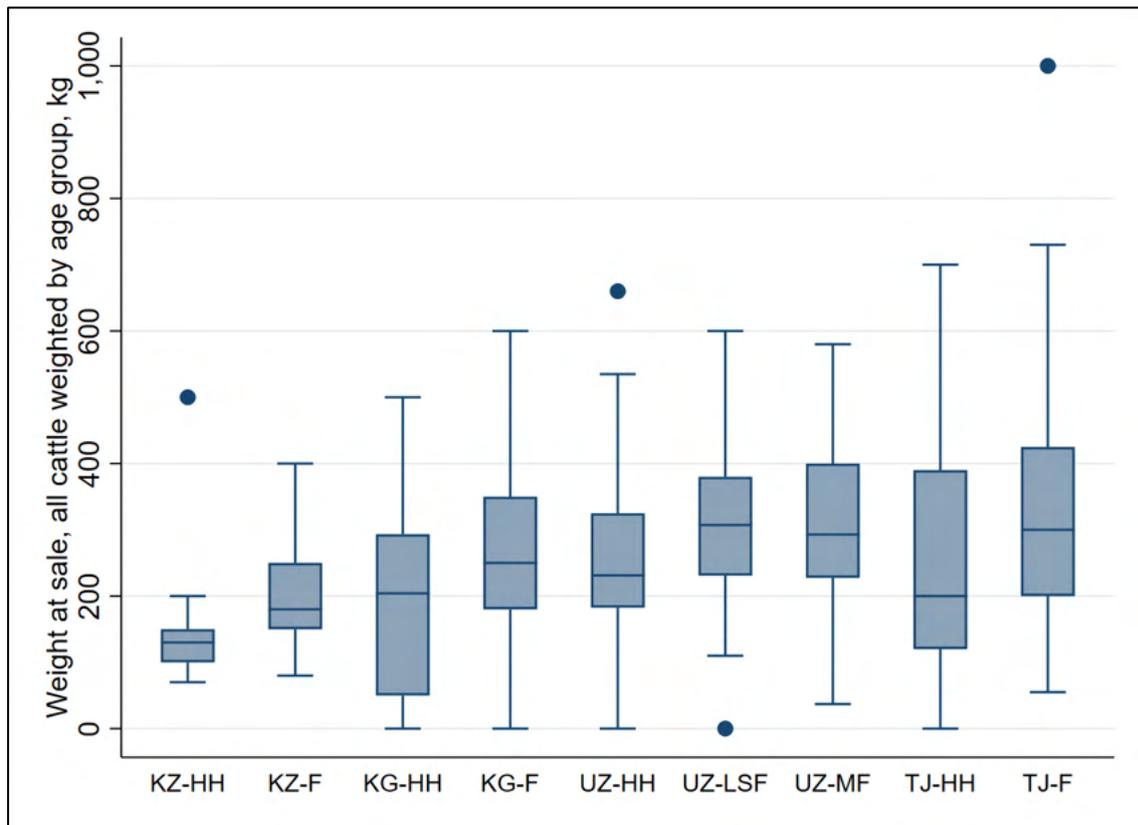


Figure A 14 Age-weighted live weight at sale by subsample

Source: Authors based on survey data.

Note: Figures for sales weight are aggregated over all age groups, weighted by the number of animals sold in each age group.

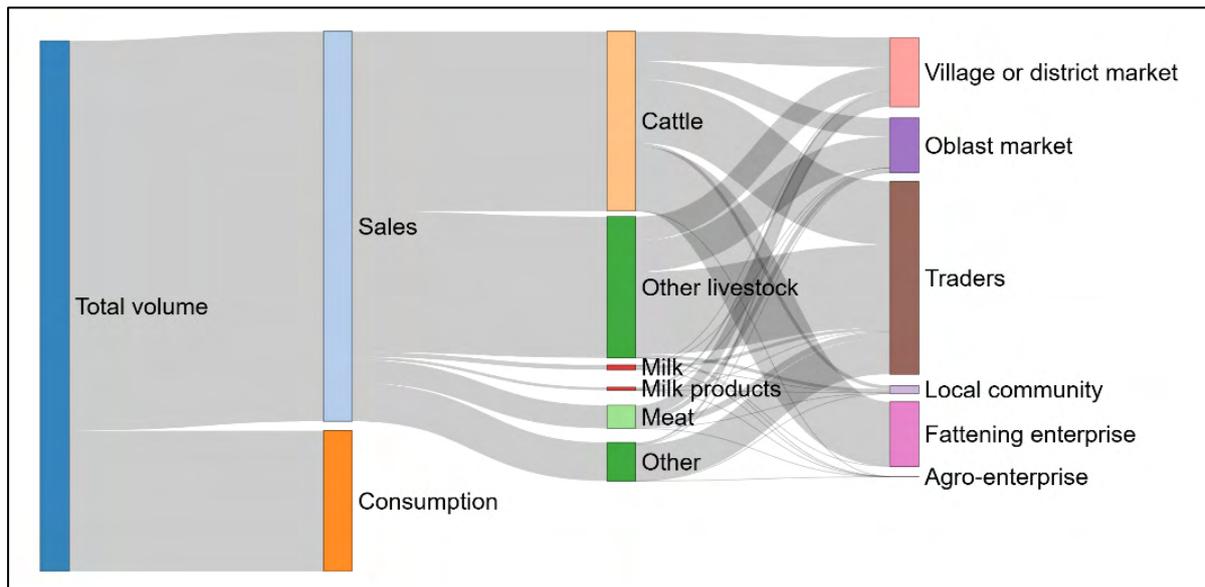


Figure A 15 Structure and sales channels of livestock output among farms in Almaty KZ

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

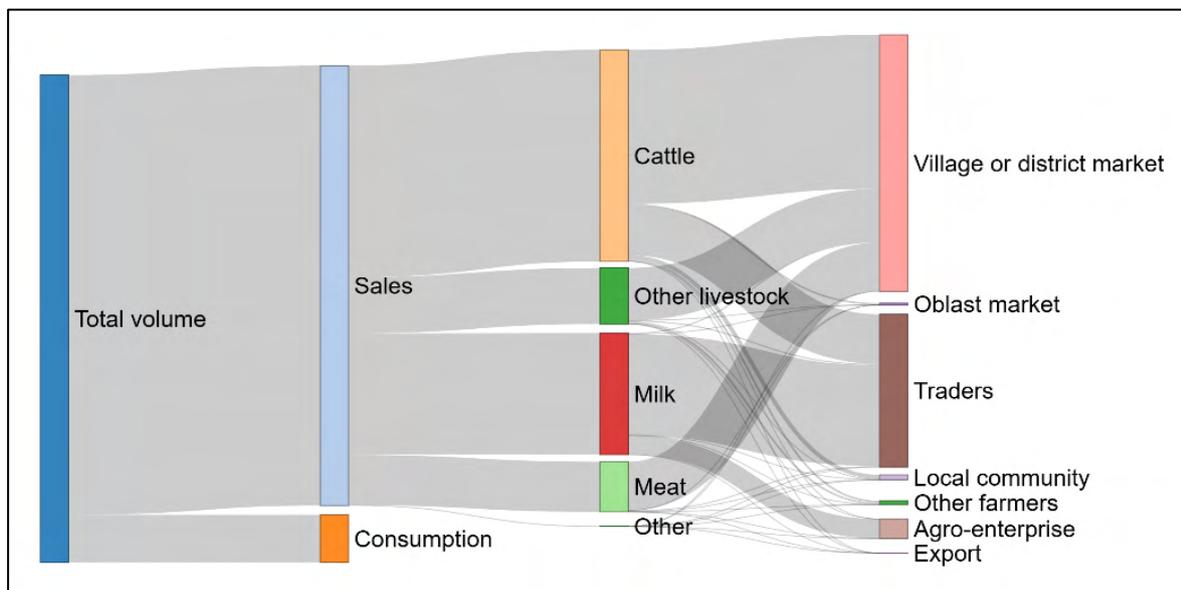


Figure A 16 Structure and sales channels of livestock output among farms in Chui KG

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

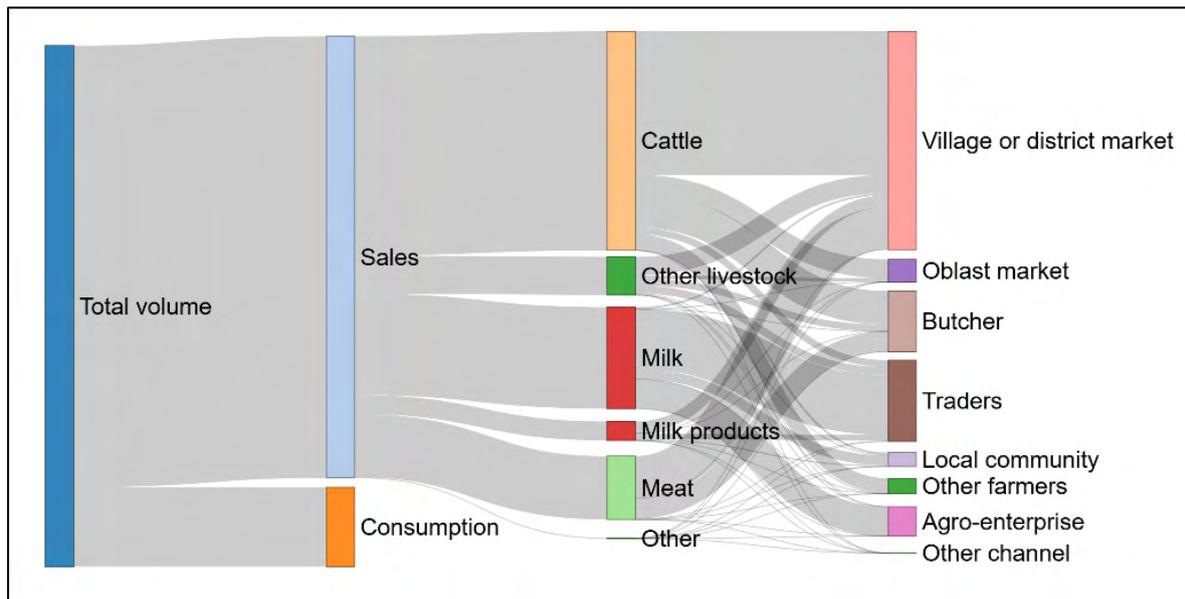


Figure A 17 Structure and sales channels of livestock output among farms in Sughd TJ

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

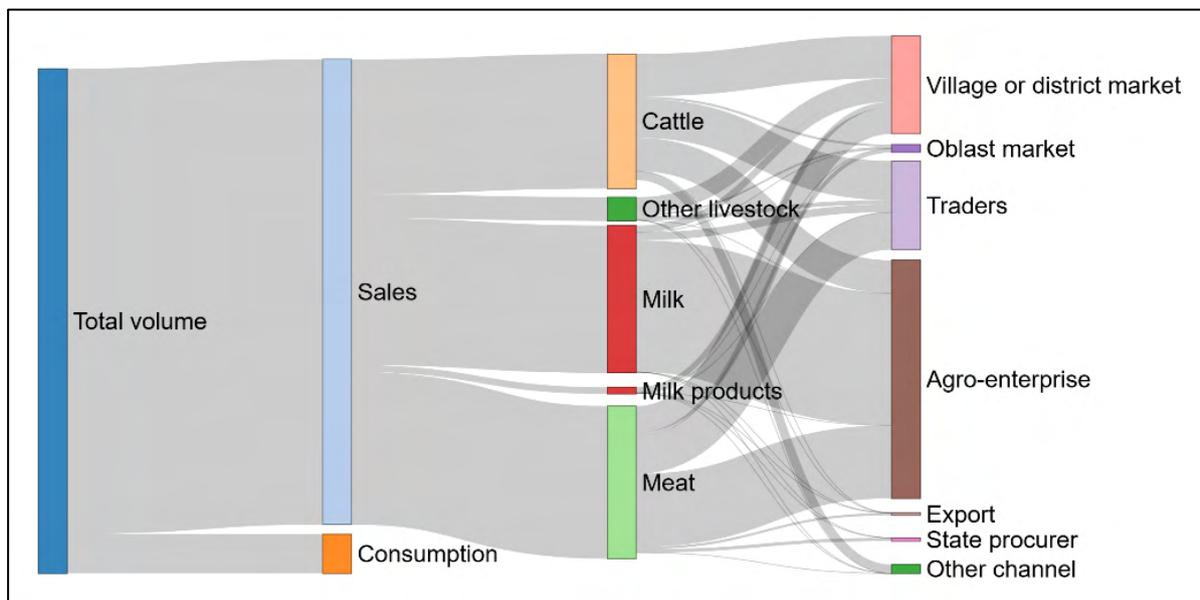


Figure A 18 Structure and sales channels of livestock output among farms in Kashkadarya UZ

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

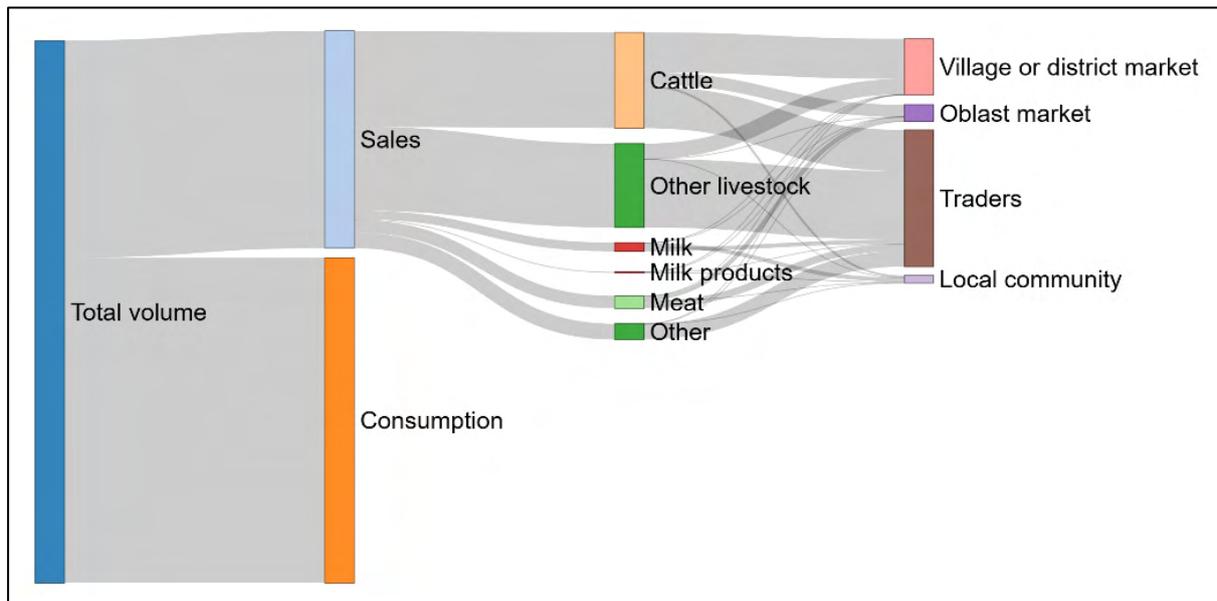


Figure A 19 Structure and sales channels of livestock output among households in Almaty KZ

Source: Authors based on survey data.
 Note: Aggregation by prices reported by individual respondents.

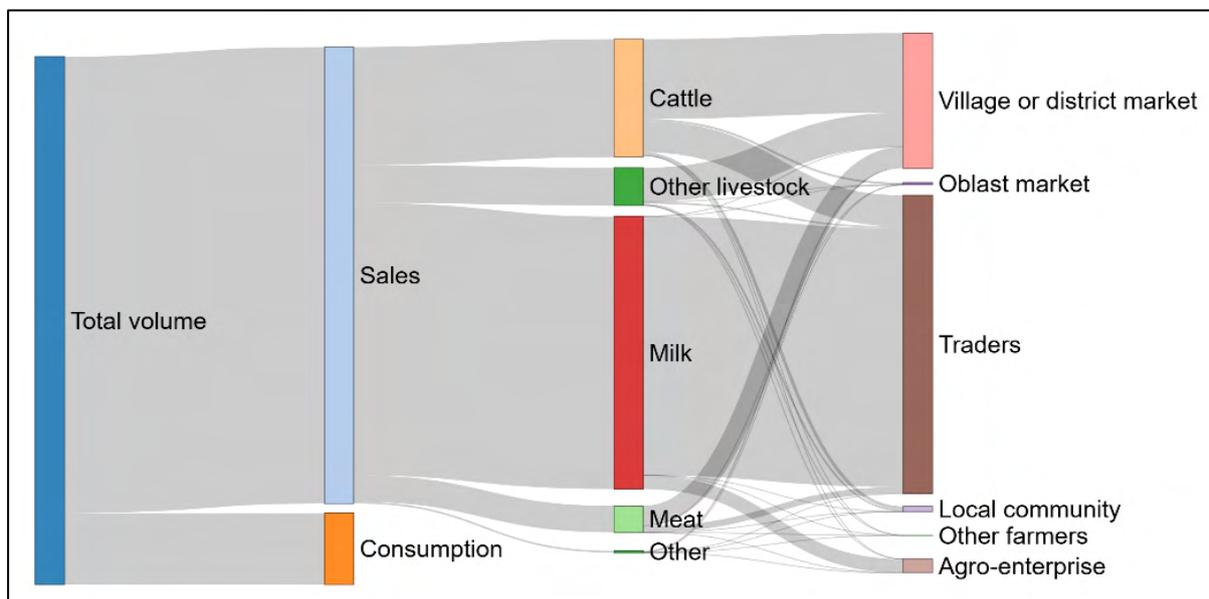


Figure A 20 Structure and sales channels of livestock output among households in Chui KG

Source: Authors based on survey data.
 Note: Aggregation by prices reported by individual respondents.

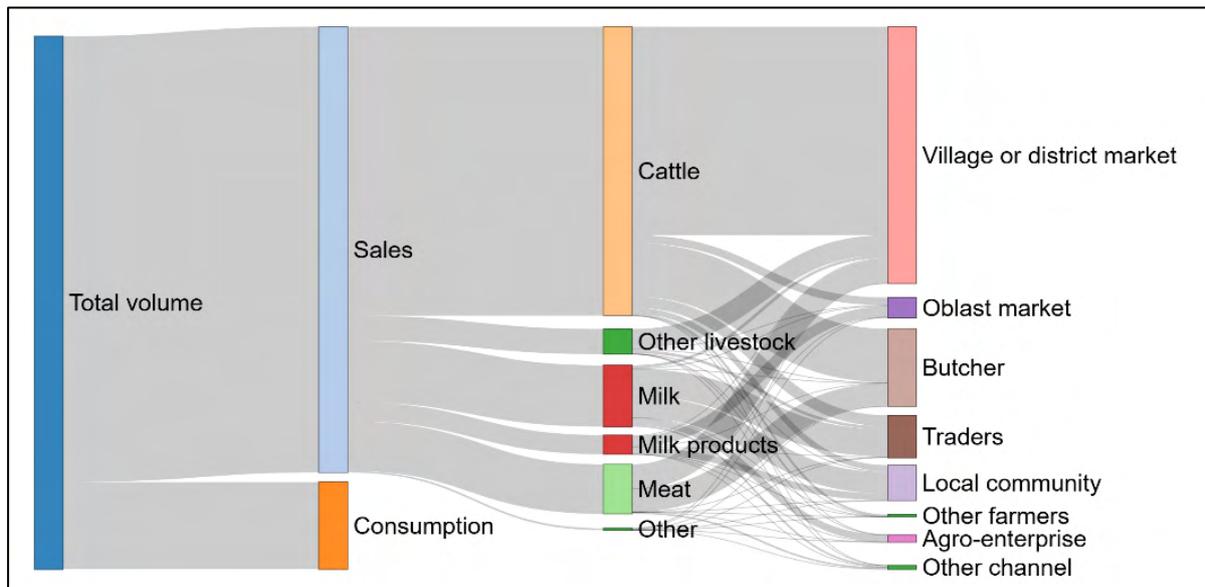


Figure A 21 Structure and sales channels of livestock output among households in Sughd TJ

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

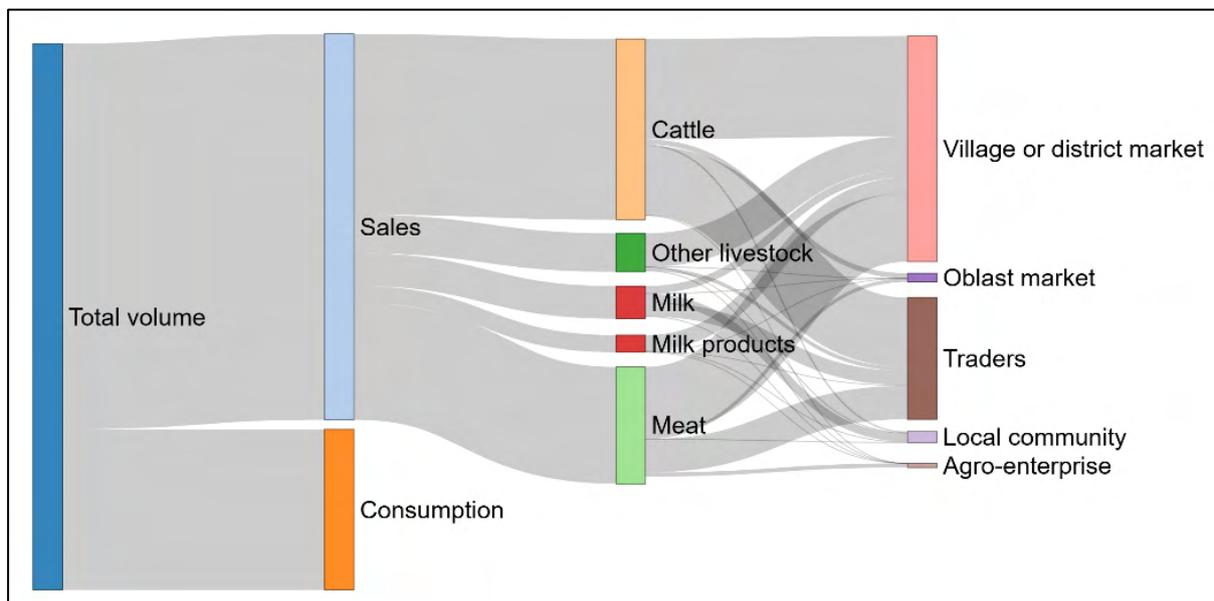


Figure A 22 Structure and sales channels of livestock output among households in Kashkadarya UZ

Source: Authors based on survey data.

Note: Aggregation by prices reported by individual respondents.

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