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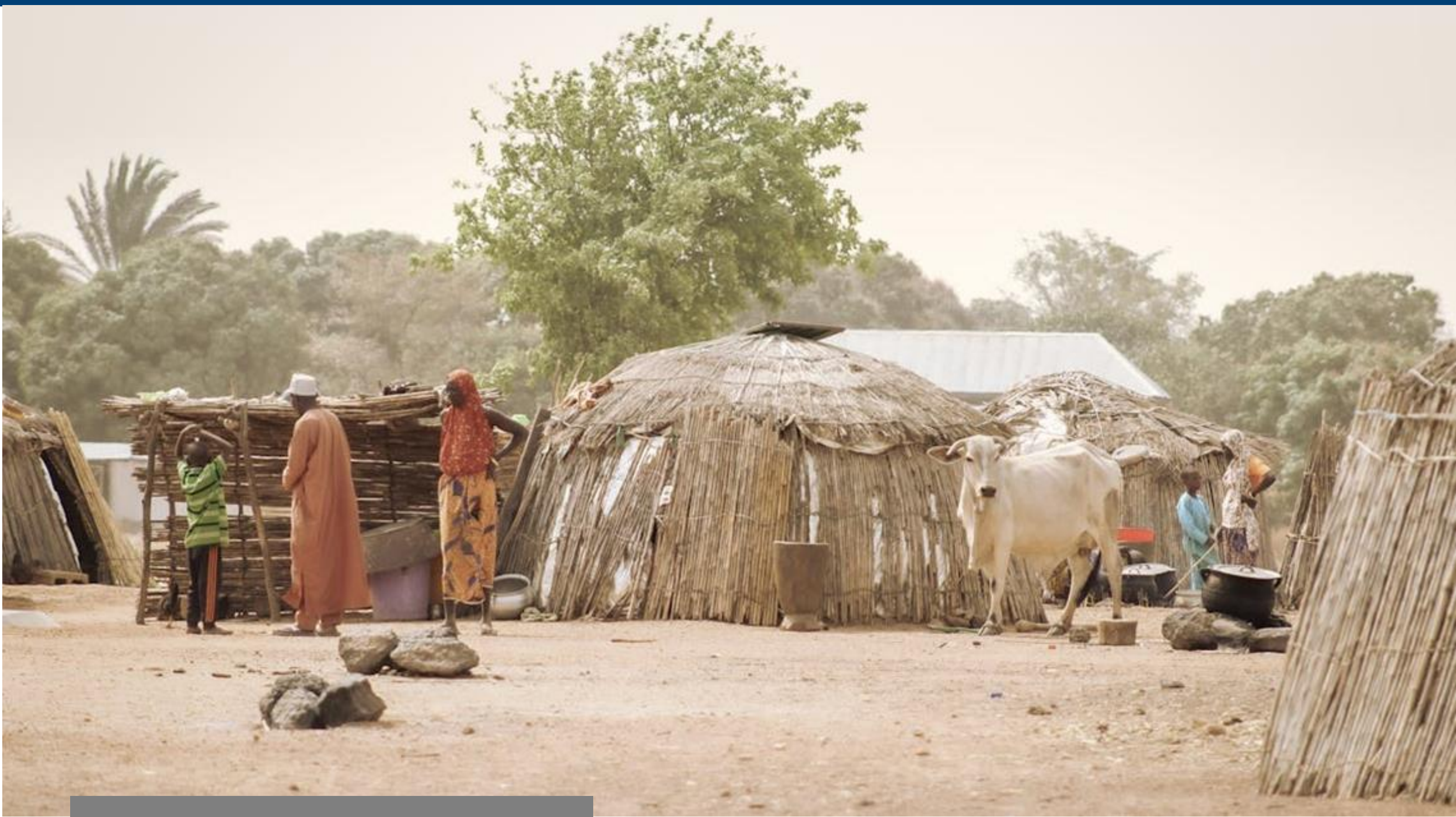

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Redefining livestock systems for sustainable transitions in Africa

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Abstract

As the livestock revolution advances in Africa, the need to increase productivity continues to pose considerable opportunities and challenges. To navigate these complexities, this study seeks to understand the diverse characteristics of livestock systems in order to explore the sustainability implications for an expanding sector. A novel conceptual framework is adopted that categorises different livestock management systems – the micro scale of livestock production - to capture the characteristics of management strategies and associated livestock production trajectories. Data were collected from study sites in Burkina Faso, Kenya, and Zambia using a combination of qualitative approaches which included historical timelines, resource mapping and focus group discussions with a representative sample of livestock sector stakeholders. The Sustainability Assessment of Food and Agriculture Systems methodology which had so far not been applied qualitatively to analyse African livestock systems further served as a comprehensive guideline for exploring the sustainability implications of changes in livestock distribution, management practices, and their drivers. The results indicate that across systems, livestock keepers are encountering multiple environmental and socio-economic pressures and opportunities, often simultaneously. In response, two main trends which can be mapped along a livestock management systems spectrum from transition to transformation were observed. Transitioning farmers changed their herd composition but maintained their existing livestock management systems; whereas, transformative farmers shifted their herding practices entirely towards new systems. Each change exhibited varying degrees of tradeoffs with respect to environmental integrity, economic resilience, social well-being and governance. The paper calls for harmonizing findings across scales to inform targeted yet flexible policies that balance productivity with sustainability. Moreover, the study stresses the importance of governance structures that can adapt to the dynamic nature of livestock systems and their socio-economic and environmental contexts.

Key Words

Livestock systems, livestock classification, trade-offs, transformations

Acknowledgments

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1. Introduction

Growth of the livestock sector presents both significant opportunities and challenges for Africa (Eeswaran et al., 2022). On the one hand, the on-going livestock revolution , propelled by rapid urbanisation and the increased demand in animal-sourced products, is likely to enhance food and nutrition security and economic development (Balehegn et al., 2020; Baltenweck et al., 2020; Latino et al., 2020). Projections (base year 2015) indicate that meat consumption will triple while dairy product consumption will double by 2050 (FAO, 2020; Malabo Montpellier Panel, 2020). On the other hand, increased livestock production can cause environmental challenges such as greenhouse gas emissions, land-use changes, and biodiversity loss (Crippa et al., 2021; Herrero & Thornton, 2013), and is accompanied by concerns related to human health such as zoonotic diseases (Latino et al., 2020) and animal welfare (Verbeke & Viaene, 2000). The role of livestock production systems, situated at the heart of the livestock sector, is therefore pivotal in shaping the outcomes of the livestock revolution in Africa.

However, different livestock systems have varying levels of productivity, efficiency, and sustainability trade-offs (Acosta & De los Santos-Montero, 2019; Descheemaeker et al., 2018; Seré et al., 1996). Livestock production systems are in a state of perpetual change and evolution, with profound effects on resource use and governance, food supply, economic growth and socio-cultural dynamics (Clay et al., 2020; Paul et al., 2020; Rayamajhi & Manandhar, 2020). These changes occur at various levels of livestock production, driven by a complex interplay of environmental, socio-economic, and cultural factors (Escarcha et al., 2018; Gebeyehu et al., 2021; Habanabakize et al., 2022). The pathways these production systems follow differ across systems, contingent upon the constraints producers face and the coping and adaptation strategies employed to navigate them (Rayamajhi & Manandhar, 2020; Sattler et al., 2021). To harness the sustainability synergies and minimise the trade-offs of the livestock revolution, major changes may be required within the diverse systems that shape the livestock landscape across Africa.

Considering the multifaceted and intricate nature of these systems, impacts and strategies can differ across systems and for distinct species and herds (Feleke et al., 2016; Guye et al., 2023; Rust, 2019; Thornton et al., 2021). The specific demands in feeding, watering, care and mobility, for each herd type, play a key role in shaping the strategy and its suitability within a particular environment marked by constraints and opportunities (Liao et al., 2020; Rayamajhi & Manandhar, 2020; Turner & Schlecht, 2019). For example, some species display superior adaptability to resource and environmental constraints (Ankrah Twumasi & Jiang, 2021; Gori Maia et al., 2018; Koluman Darcan & Silanikove, 2018; Nair et al., 2021; Radolf et al., 2022), whereas others are more resistant to diseases (Nair et al., 2021) and tolerant to heat. As changes occur across scales, livestock keepers adjust their management practices (Kuchimanchi et al., 2021; Ouédraogo et al., 2021; Sattler et al., 2021), engendering trade-offs, which need consideration in the broader context of livestock development (Godde et al., 2018; Herrero et al., 2009; Murali et al., 2020; Paul et al., 2022; Paul et al., 2020).

Amidst ongoing socioeconomic and environmental changes, distinguishing among different systems is essential to formulate policies that support the transition process, and tailor interventions that promote sustainable livestock development. Given the multiple dimensions of sustainability, a more holistic classification that embraces different variables is likely to offer more insights into the challenges and opportunities that underlie concurrent livestock pathways. Furthermore, such insights may strengthen the capacity of livestock keepers, while ensuring food and nutrition security, socioeconomic and livelihoods development. Livestock systems classifications provide frameworks for uncovering the structures of specific systems and assessing the transformations occurring within each (Eeswaran et al., 2022), while identifying prospects for sustainability (Friedrich et al., 2021; Rauw et al., 2020). By classifying livestock systems and comprehending the trade-offs involved, stakeholders can make informed decisions about the potential advantages and disadvantages of specific livestock practices (Godde et al., 2018; Paul et al., 2022; Paul et al., 2020). To date, most classifications focus on discrete components of livestock systems, classifying them based on single or few predetermined criteria. These criteria often encompass considerations such as agro-ecological conditions, animal traits (Otte & Chilonda, 2003), feeding strategies and production goals. Attempts at developing a classification which combines the multifaceted (encompassing both biophysical and socio-economic) dimensions of livestock systems are limited (Pandey and Upadhyay, 2022). Furthermore, only very few classifications consider the motivations of livestock keepers and their heterogeneity, even though production decisions are closely tied to their specific opportunities and preferences (De Glanville et al, 2020).

This paper presents a classification that begins to address these limitations. It does so by applying an innovative approach to livestock classification, which accounts for the inherent complexity of livestock systems. This classification encompasses multiple and diverse dimensions of livestock production and extends beyond system classification down to the micro level. This approach is founded on the principle that every primary livestock system consists of distinct smaller units, each subject to unique management practices and production functions. “Herd types” are categorised on the basis of herd composition and size, production goals and economic function, feeding strategies (crop residues, feed supplements; pasture), mobility patterns (joint and long-distance herding) and confinement strategies. In the context of this paper, "herd type" refers to a group of animals (single or multiple species), that are managed collectively. Every herd consists of livestock that are herded, watered, confined and cared for in the same manner. We use the framework to identify and assess changes and trends in livestock management and production systems, and delve into the trade-offs inherent in the process of change. In so doing, the study aims to: 1) Identify the transitions in livestock management practices (the different pathways in terms of herd management); 2) Synthesise the drivers of these transitions (both positive and negative) and 3) Uncover the potential sustainability trade-offs underlying systems transformation.

The framework is applied to three countries in west, east and southern Africa, namely Burkina Faso, Kenya, and Zambia, to compare and contrast systems. The three countries were involved the “Program of Accompanying Research for Agricultural Innovation” (PARI) funded by the German Federal Ministry of Economic Cooperation and Development (BMZ). These countries are characterized by a diversity of production systems and livestock plays a central role in the economies of these nations (Eeswaran et al., 2022; Behnke & Muthami, 2011). Livestock serves as a vital source of income and food security for a substantial portion of the population (Escarcha et al., 2018; Friedrich et al., 2021). Moreover, the consumption of animal-sourced foods (ASF) serves as a significant source of dietary protein (Enahoro et al., 2018; McDowell, 2019).

The regions of Africa in the study present both similarities and differences with regards to livestock practices (Campbell et al., 2021; Seter et al., 2018; Vall et al., 2021). Compared to west Africa, the eastern part of the continent is characterised by greater livestock diversity (Rodrigues et al., 2017) and wildlife-livestock interactions are more common (Craighead et al., 2018; Turner et al., 2016). Conversely, crop-livestock interactions represent more than 40% of livestock practices in west Africa (Malabo Montpellier Panel, 2020), whereas pastoralism is predominant in the Eastern region (Boutrais, 2016; Dong, 2016). Within each region, differences may also occur as a result of intra-country policies and governance structures (Haller et al., 2016; Senda et al., 2020; Seter et al., 2018; Sharifian et al., 2022), and historical reasons, affecting the choices made by livestock keepers. The paper adopts a comparative methodology to elucidate these similarities and disparities, and explain the underlying factors that may account for divergent trajectories within seemingly similar contexts. Moreover, the paper will also help identify the pathways that are likely to support the livestock revolution, while mitigating sustainability trade-offs associated with livestock development.

The following sections are structured as follows: In the forthcoming section, we introduce the conceptual framework that underpins this study. Subsequently, we present the methodologies used for data collection and analysis. The next section focusses on the empirical findings followed by a discussion and conclusion in the final sections.

2. Conceptual Framework

The study posits the thesis that existing livestock systems classifications are not always optimal for analysing and intervening in African livestock production systems. Firstly, because the majority of classifications tend to be conceptualised on a global scale (rather than at a high resolution) which offers an understanding of overall trends. However, also minimises their practical use for priority setting and planning at national or subnational levels and can lead to ineffective resource allocation and policy development. Secondly, because those classification systems that focus on the household level, tend to undermine the ability to accurately capture relevant complexities driving livestock production. Namely, the dynamic, social, economic, and environmental changes related to herd management that are occurring in many parts of Africa. These drivers may lead to the emergence of new, non-traditional strategies for livestock management. Traditional classification systems often do not adequately capture change and innovation in livestock management practices limiting their usefulness in understanding and addressing the challenges faced by livestock keepers.

Production and livestock management systems

We define a production system as the set of similar herd management practices that are applied in individual herds and yet reflecting a specific group of herds. The livestock are herded either according to the intended purpose and nature of groups or individuals' particular management practices, be it grazing or confinement. These management practices manifest themselves through feeding strategies, within enterprise interaction (for example within farm crop-livestock interactions), mobility patterns and production goals. Herds that fall into the same production system typically face similar challenges and can be targeted by similar interventions and development strategies. As a livestock keeping household may manage multiple such production systems, e.g. free roaming chicken, pastoral work oxen and stallfed dairy cows, discerning management practices on herd and flock level allows for the appreciation of diversity in production systems that coexist at the lowest scale of the household level. We detail the production systems that we identified in the study area below. A comprehensive list of livestock production systems in Africa has been published elsewhere (Graf & Chagunda, forthcoming).

In the free-range systems livestock are let out in the morning to roam and scavenge unsupervised and unconstrained by fences. Ruminants may be fed crop residues additionally (Gondwe and Wollny, 2007; Thys et al., 2016). In this low-intensity system, increasing number of offspring is the main production goal (Kondombo et al., 2003; Mtileni et al., 2012; Harpal Singh, 2015) – making fertility and mortality the primary concern in the system. The paradox, however, is that with free-ranging comes high offspring mortality due to different management and environmental reasons.

In seasonal free ranging systems livestock roams freely during the dry season, and are confined during the rainy season to avoid crop damage. During the rainy season animals may be herded, tethered or kept in a stable (Siegmund-Schultze et al., 2012; Urgessa et al., 2012; Kagira et al., 2010; Tindano et al., 2015). As in the free range system, interventions focus on fertility and mortality.

Sedentary ruminant production systems refers to animals that are herded to graze on pastures but return to the same encampment every evening. These herds are kept mainly for reproduction (Armbruster and Peters, 1993; Kalinda, Filson and Shute, 2000).

Herded dairy production systems are common among households that manage multiple ruminant herds. Lactating cows and calves are herded from a village-based enclosure to the pasture each day. Milk and offspring are key production goals in this production system (Mwacharo and Drucker, 2005). Expansion of fields increasingly complicates grazing during the rainy season (Dongmo et al., 2012; Liao et al., 2017), creating farmer-herder conflicts. This becomes a key concern in the system.

Herd sub-systems

Herd subsystems describe practices that apply to only some animals in a herd or a seasonal variation that can be combined with multiple herd types.

Pastoral work oxen are animals used for ploughing that are herded most of the year. As these are typically few animals per household they could be incorporated in a households sedentary ruminant herding or dairy herding system (Dongmo et al., 2012; Moll, Staal and Ibrahim, 2007) or pooled together with ploughing animals of multiple households (Lubungu, 2018). The presence of pastoral work oxen may indicate that intensification of crop production may be viable in an area.

Rainy season transhumance addresses herding constraints during the rainy season, usually abundant crop fields. Thus, this system often involves moving cattle to more arid regions (Turner et al., 2011; Shinjo, 2017). A transhumant herd usually consists of the household’s male cattle, dry cows and a small number of lactating cows to supply milk for herders – while the dairy herd would stay behind.

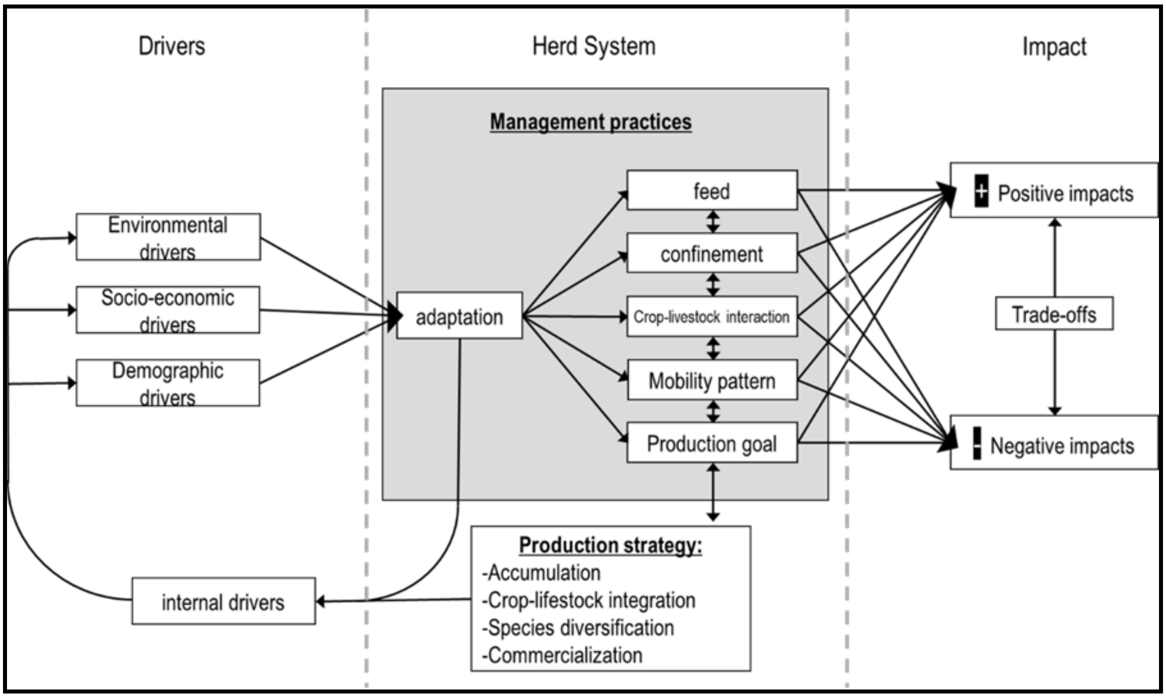
Dry season transhumance addresses grazing constraints during the dry season and is thus driven by a search for water and pasture resources, if local resources diminish (Adriansen, 2002 Paper D). To be viable, such herd movements need to exploit a spatial gradient (altitude, latitude, floodplains), that outweighs the energy animals required to walk (Turner and Schlecht, 2019). Movement with animals can be distinguished between long and short distances depending on environmental and socioeconomic factors such as land tenure.

System Transformation Pathways

Given the interconnectedness of the practices that define a production system, adjustments in one aspect of livestock management (e.g. feeding) can lead to a chain of changes resulting in new livestock management systems following a new production strategy. This can include changed production intensity, purpose of production, composition of livestock species and breeds, management practices, or organisation of production, so that livestock management systems will be classified differently regarding the above categories. A livestock transformation pathway accordingly includes the process and drivers that lead to fundamental and incremental changes in the production strategy in a way that after a period of time a different livestock management system has emerged.

Production system transformations are complex and iterative processes that result from an interplay of drivers that can be both external and internal to the system. External drivers include environmental, social and demographic drivers, like climate change, conflict or population growth. Livestock managers will adapt to these drivers by changing aspects of the management system. Such adaptation may make further adjustments necessary; for example, if grazing is reduced because of changes in land-use, alternative feeding strategies must be organized. Internal drivers result directly from the production system of the herd. For example, following an accumulation strategy geared towards herd growth without monitoring grass availability and grass quality, can lead to overgrazing, resulting in environmental pressure to adapt management practices.

Figure 1. Conceptual framework



Source: Sarah Graf

Beyond changes in the herd dynamics, transformations in the production system lead to changes at different levels, that is, at farm, community and landscape levels both materially and institutionally.

Such changes can have both positive and negative impacts on environmental, economic, and social goals. Some of these impacts may even be directly conflicting with each other. Figure 1 depicts potential drivers and pathways of such production system transformation. In the example above following an accumulation strategy, the positive economic change - herd growth – can be accompanied with negative environmental side effects such as overgrazing. As positive and negative impacts are often directly linked to each other, it is necessary to acknowledge, minimize and manage these trade-offs in order to design sustainable production systems transformation pathways. Consequently, it is paramount to initiate or influence such processes in a way that creates transformation pathways towards more sustainable, equitable and fair systems.

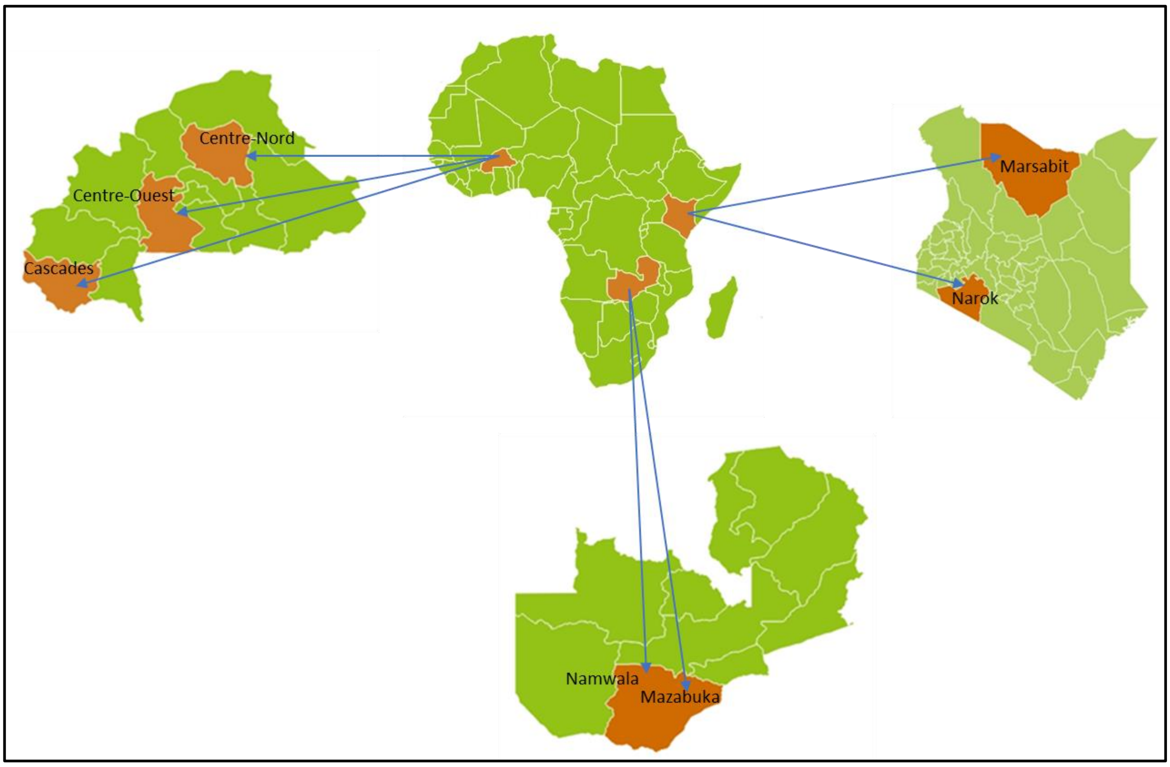
3. Methodology

The African livestock sector is at a critical juncture, facing a complex interplay of opportunities and pressures that impact both productivity and sustainability. Given the diverse variables under study and the need to ensure empirical rigor, a combination of qualitative approaches was applied across multiple scales. The benefit of this combined approach is to capture a comprehensive understanding of the phenomena under investigation, and also to compare, contrast and ultimately verify different results through alternative methods. This section presents an overview of the study sites, data collection methods, sampling procedures and analysis.

Study sites

Burkina Faso, Kenya and Zambia were selected for this study to represent a variety of systems in west, east and southern Africa (Figure 2). The countries were considered suitable examples due to the similarities and differences of production systems they host as well as their different stages of commercial development.

Figure 2. Hypothetical cost curves of agricultural mechanization



Source: Authors (Made with Visme)

Livestock contributes considerably to national GDPs of all three countries ranging from 20% in Burkina Faso to 30% in Zambia with the share of the population employed in the sector at approximately 50% to 86% in Zambia and Burkina Faso, respectively. In as far as possible, the regions and study sites were selected to provide as representative examples of the diversity of livestock production across the three countries. Particularly, the study was conducted with respondents across 12 villages which varied in terms of population and area (km^2), agro-ecological zone (AEZ) and livestock species diversity. Semi-arid systems were the most common AEZ, whereas, arid systems were represented to a lesser degree. Goat production existed across all sites, sheep and poultry production in the majority of sites and camel and pig production was unique to Kenya and Zambia respectively. Collectively, the countries present a valuable opportunity from which livestock production systems, herd management strategies and system transitions can be examined. Table 1 illustrates the characteristics across study sites.

Table 1. Study countries in Africa (Sources: Ministry of Livestock and Fisheries Burkina Faso, 2018; Kenya National Bureau of Statistics, 2019; Zambia National Livestock Development Policy, 2020)

	Burkina Faso				Kenya				Zambia			
Region/ County	Centre-Nord	Centre-Ouest	Cascades		Narok		Marsabit		Mazabuka		Namwala	
Population	1,872,126	1,659,339	812,466		1,157,873		459,785		194,653		126,775	
Village	Korsimoro	Cassou	Vrassane	Mitieredougou	Suswa	Ololunga	Ngurunit	Korr	Munjile	Itebe	Mukobela	Maala
Population (village)	15,994	5,485	1,216	2,464	5,592	16,242	3,090	3,332	2,508	2,856		5,776
Area (km²)	603.4	1,170	No data available	No data available	17,950.3		70,944.1		6,242		5,687	
Livestock share of GDP (%)	20				26				30			
Share of population employed in livestock (%)	86				70				>50			
Agro-ecological zone	Arid	Semi-arid	Semi-arid	Semi-Arid	Semi-arid		Arid		Semi-arid		Semi-arid	
Dominant livestock species	Poultry Donkey Sheep Cattle Goat	Poultry Goat Sheep Cattle Donkey	Poultry Goat Sheep Cattle Donkey	Poultry Cattle Goat Sheep Pig	Sheep Goats Cattle Poultry		Sheep Goats Cattle Camels		Sheep Goats Cattle Pigs Poultry		Cattle Goats Poultry	
Dominant Land tenure system	Private (customary tenure)	Private (customary tenure)	Private (customary tenure)	Private (customary tenure)	Private (formal tenure)		Communal		Communal		Communal	

Source: Authors

Data collection and analysis

The diversity of variables incorporated into the livestock classification approach lends itself to a qualitative approach to allow for a detailed understanding of livestock management activities across multiple scales and landscapes (Cresswell, 2009; Yoshikawa et al, 2008). Qualitative methods were conducted at the community level and consisted of participatory methods such as an historical timeline activity with community elders, focus group discussions (FGDs) accompanied by a livestock management systems identification and resource mapping activity with livestock keeping villagers.

The historical timeline activity entailed asking focussed questions with long term residents from the study area. The activity developed a calendar of critical events over a 30-year period that have shaped livestock production such as succession of droughts, livestock disease outbreaks and the introduction / cessation of agricultural projects. The FGDs addressed multiple objectives. Livestock management systems and transitions were jointly identified and discussed using animal toys and drawings. Discussions were facilitated around patterns of livestock ownership, breeds, and herding systems. Whereas, the resource mapping activity entailed the collaborative production of two maps per site representing the years 2000 and 2021 (2001 and 2022 in the case of Burkina Faso) to allow for comparing and contrasting changes in the village level resources and prioritising the underlying drivers of change. During the activity participants created hand-drawn maps with symbols to represent different resources, landmarks, and structures within the village. The production of two maps allowed for visualisation of changes in resource use and distribution. Participatory activities and FGDs conducted with small groups of individuals are an efficient and interactive group-based approach for generating contextual community-level information (Morgan 1998). FGDs are particularly efficient because a wealth of information is generated during a single event. An illustration of the activities is presented in Figure 3.

At the household level, semi-structured homestead interviews (HIS) along with a detailed assessment of livestock management practices were conducted. This approach allowed for rich understanding, supplemented by on-site observations of actual livestock management practices, opportunities and constraints. Questions focussed on household member composition, labour practices, land and livestock assets. Answers provided were verified with 'transect walk' observations complemented by further discussions about livestock breeds, feeds, productivity and other farming aspects of importance to the study.

In collaboration with in-country PARI partners (Kenya Agricultural Livestock Research Organisation and the Indaba Agricultural Policy Research Institute in Zambia), expert interviews delivered through semi-structured questionnaires were conducted with actors involved along different stages of the livestock value chain. Interviewees included medium and large-scale farmers, veterinarians, extension officers, agro-shop dealers, meat processors, non-governmental organisations (NGOs) and former ministers. Due to the different types of expertise, a checklist which focussed on livestock development trade-offs and solutions was developed.

All data collection tools were informed by the Food and Agriculture Organisations (FAO) Sustainability Assessment of Food and Agriculture Systems (SAFA) methodology (FAO, 2014). The SAFA guidelines and assessment tools comprise of over 400 different sustainability indicators covering four overarching sustainability domains, namely, economic, social, institutional and governance aspects. Only the domains considered feasible and directly relevant to answer the three main research questions were utilised. At the time of the study, the SAFA methodology had not been applied qualitatively to analyse African livestock systems, presenting a particularly strong case for adopting the selected approach to help bridge the research gap in this field of study. A summary of the methods applied for the corresponding questions is illustrated below in Table 2.

Table 2. Summary of data collection tools and research questions answered

	HISTORICAL TIMELINE	FGDs		HOMESTEAD INTERVIEWS	EXPERT INTERVIEWS
		Herd identification	Resource mapping		
Q1: What changes have taken place in livestock systems in the past 30 years?					
Describe the changes in livestock management systems, dominant livestock trends and drivers of livestock system transformations	X	X	X	X	X
Illustrate the changes in resources (environmental; institutional etc) over the past 10 years		X	X	X	X
Q2: What are the trade-offs associated with these changes?					
Identify nutritional and socio-economic changes emerging from the livestock systems transitions		X	X	X	X
Q3: How are trade-offs being addressed?					
Review current policy documents pertaining directly to trade-offs of interest and determine whether they are facilitating or inhibiting impacts					X

Source: Authors

Sampling

A combination of sampling methods was used to gather information from the various categories of respondents in an effort to uphold a representative picture of livestock production systems in the study sites. Snowball sampling (Johnson, 2014) was employed for the historical timeline activity to identify participants with long term knowledge and understanding of the study sites. Whereas stratified sampling (Simkin, 2022) was used to identify FGD participants based on available lists and registers with farmer details provided either by extension officers (Zambia) or local leaders / chiefs (Kenya), and village development counsellors (Burkina Faso). In as far as possible, the study sought to capture the voices of men and women. Household interviewees of two male and one female headed household were further sampled from FGDs in a participatory process where discussants short-listed a number of households and then prioritised the most suitable households based on an agreed upon set of criteria. Whereas, expert interviewees were purposefully sampled with the assistance of project partner staff and agricultural extension agents. Purposeful sampling was considered necessary for identifying respondents with specialised knowledge on and experience with key aspects of the topics under study. Table 3 presents a summary of the sampled interviewees and group discussants.

Table 3. Summary of data collected

	HISTORICAL TIMELINE			FGDs			HOMESTEAD INTERVIEWS		EXPERT INTERVIEWS
	Male	Female	Mixed	Male	Female	Mixed	Male	Female	Male and female
Burkina Faso	4	0	0	8	8	0	9	5	5
Kenya	4	0	1	3	3	2	2	2	18
Zambia	3	2	1	0	0	5	8	4	14

Source: Authors

Data recording, analysis and ethical clearance

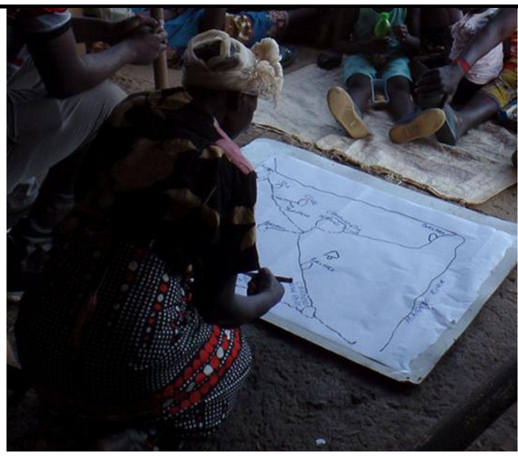
Data was recorded using methods including memo-style notes, direct data entry into physical questionnaires and recording of data using a portable recorder, the latter of which was transcribed. Data was also recorded through photographs taken as a visual reference for specific livestock species and practices. The information collected was entered into a database with the help of a translator where necessary to ensure for quality and accuracy.

Audio recordings were only conducted with the consent of all interviewees and discussants with additional agreement that all reporting would be submitted under strict confidentiality. All photos, voice recordings, and direct quotes from respondents were taken and used with their permission and the assurance that anonymity would be maintained. These practices are in accordance with the ethical clearance which was granted by the University of Hohenheim after a rigorous review of the proposed study.

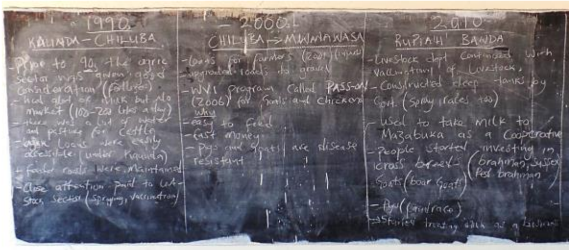
Qualitative data was analysed inductively using a content analysis approach (Glaser and Strauss, 2017) to identify and systematically organise emerging and unique trends across the data. The data from all the activities was structured in a text document under the subcategories and the validation was proofed by the consensus of the results different activities.

Figure 3. Data collection with participatory approaches in Burkina Faso, Kenya and Zambia

Herd identification in Burkina Faso



Resource mapping activity in Zambia



Timeline Activity in Zambia

Herd identification in Kenya

Resource mapping activity in Kenya

Source: Bethany Laffoon, Joshua Grau and Viviane Yameogo

4. Results

Subsequent sections will present the major changes occurring within different livestock management systems, and elaborate on the drivers of change. Furthermore, the sustainability trade-offs underlying these livestock trajectories will be explored.

4.1 Herd types and composition

Table 4 illustrates the distinct herd types encountered within the study sites. These herd types coexist in various agro-ecological settings, and are characterised by specific herd composition (flock size and species distribution), mobility patterns, confinement and feeding strategies, and economic and production goals. While some herd types are found in all sites, others exist in specific agro-ecological zones. For instance, seasonal free-roaming is practised in both arid and semi-arid regions. This practice consists of herds composed of a single species or the joint herding of several species. While we observe cattle-only herds, subsets of seasonal free-roaming herds encompassing both sheep and goats (Kenya and Zambia), sheep only (Burkina Faso), combinations of cattle and donkeys (Kenya), and pigs (Zambia) were also identified. Similarly, sedentary ruminant herding prevails in seven of the twelve study areas. This herd type is found in semi-arid regions and primarily consists of sheep and goats. Nevertheless, there exist sedentary ruminant herds comprising cattle and sheep, and in some cases, encompassing joint herds of goats, sheep, and donkeys, as respondents in Zambia indicated. Of comparable significance is the prevalence of the free-roaming herd type, primarily identified in semi-arid regions of the three study countries. This category predominantly comprises poultry (chicken and ducks in Zambia), and joint herds of cattle, sheep, and goats (Kenya) and sheep (Burkina Faso). Similar herd types extend to pigs and ploughing bulls within the Zambian context.

The occurrence of some herd types is country or site-specific. Notably, the rainy season transhumance herds are confined solely to the semi-arid and Sudanian regions of Burkina Faso. This practice largely entails cattle herds and necessitates considerable long-distance mobility, including cross-border movement. Likewise, stall-fed oxen, and dairy husbandry—largely practiced by the Fulani community—stand out as distinctive herd types documented within Burkina Faso. Notably, these herd types exclusively comprise cattle and are localised within the semi-arid and Sudanian landscapes of the country. Similarly, mobile herds are only encountered in Kenya comprising of camels in the arid regions. Less frequent herd types also include dry season transhumance in the semi-arid zones of Kenya. This herd type consists of cattle and sheep with goats herded separately.

Table 4. Herd types distribution in selected study areas

Country	Region	Village	Agro-ecological zone	Herd type	Livestock species
Burkina Faso	Centre-Ouest	Cassou	Semi-arid	Rainy season transhumance	Cattle
				Sedentary ruminant herding	Cattle & sheep
				Seasonal free roaming	Sheep
				Stallfed work oxen	Cattle
	Centre-Ouest	Vrassane	Semi-arid	Rainy season transhumance	Cattle
				Seasonal free roaming	Sheep
				Stallfed work oxen	Cattle
				Dairy herding (Fulani)	Cattle
	Centre-Nord	Korsimoro	Semi-arid	Rainy season transhumance	Cattle
				Dairy herding (Fulani)	Cattle
				Sedentary ruminant herding	Cattle & sheep
				Stallfed work oxen	Cattle
	Cascades	Mitieredougou	Sudanian	Rainy season transhumance	Cattle
				Seasonal free roaming	Sheep
				Stallfed work oxen	Cattle
				Dairy herding (Fulani)	Cattle
Kenya	Narok	Suswa	Semi-arid	Sedentary ruminant herding	Cattle & sheep; goats
				Dry season transhumance	Cattle & sheep; goats
				Free roaming	Cattle, sheep & goats
		Ololunga	Semi-arid	Sedentary ruminant herding	Cattle & sheep; goats
				Dry season transhumance	Cattle & sheep; goats
				Free roaming	Cattle, sheep & goats
	Marsabit	Ngurunit	Arid	Mobile herd	Camels
				Seasonal free roaming	Sheep & goats
				Seasonal free roaming	Cattle & donkeys; cattle, camels & donkeys
		Korr	Arid	Mobile herd	Camels
				Seasonal free roaming	Sheep & goats
				Seasonal free roaming	Cattle & donkeys; cattle, camels & donkeys
Zambia	Mazabuka	Munjile	Semi-arid	Free roaming	Chickens
				Sedentary ruminant herding	Sheep & goats
				Seasonal free roaming	Cattle
		Itebe	Semi-arid	Free roaming	Chickens
				Free roaming	Pigs
				Seasonal free roaming	Cattle, including ploughing bulls
				Milking cows	Cattle
				Sedentary ruminant herding	Sheep & goats
	Namwala	Mukobele	Semi-arid	Seasonal free roaming	Cattle
				Free roaming	Ploughing bulls & oxen
				Free roaming	Chickens
				Seasonal free roaming, free roaming	Pigs

				Sedentary ruminant herding	Sheep, goats & donkeys
		Maala	Semi-arid	Seasonal free roaming	Cattle
				Free roaming	Chicken
				Seasonal free roaming	Sheep & goats
				Seasonal free roaming	Pigs
				Free roaming	Ducks

Source: Authors

4.2 Overview of changing livestock management practices and drivers

The results reveal that over time, some herds types have declined, while others have increased. Some herds types have also emerged as a result of this gradual evolution. The specific characteristics of herd types identified present a snapshot of spatial and temporal transformations that are a result of the ongoing evolution of the overall livestock landscape. Table 5 shows the changes operating within the herd types encountered in the selected case countries. These changes apply to various dimensions of livestock management practices, comprising, i) flock size and distribution, ii) mobility and confinement strategies, iii) feed and feeding strategies, and, iv) economic functions. The results illustrate these interrelated management strategies across countries and agro-ecological zones, with implications for the trajectories of the different herd types.

Table 5. Changes in livestock distribution and management practices

		COUNTRY LEVEL											
Major Changes	**Specific changes**	**Burkina Faso**				**Kenya**				**Zambia**			
		Semi-arid			**Sudanian**	**Semi-arid**		**Arid**		**Semi-arid**			
		Centre-Ouest		Centre-Nord	Cascades	Narok		Marsabit		Mazabuka		Namwala	
		Cassou	Vrassane	Korsimoro	Mitieredougou	Suswa	Ololunga	Ngurunit	Korr	Munjile	Itebe	Mukobele	Maala
Livestock distribution (size)	Cattle	-	--	+	++	-	-	-	-	+++	+++	+++	+++
	Sheep	+	-	++	0	+	++	--	---	+	++	+++	+++
	Goat	++	++	++	++	-	-	++	+	+	++	+++	+++
	Chicken/guinea fowls	++	++	++	++	+	+	n/a	n/a	+	0	+	+
	Camels	n/a	n/a	n/a	n/a	n/a	n/a	++	++	n/a	n/a	n/a	n/a
Feeding strategies	Crop residues	+++	+++	+++	+++	nd	+	+	0	0	0	0	0
	Feed supplements	+	+	++	+	nd	nd	0	0	++	+	+	0
	Pasture	--	---	---	--	---	--	--	--	0	0	0	0
Mobility patterns	Joint herding	---	---	---	---	---	---	nd	nd	++	0	0	+
	Long distance	--	++	---	++	--	--	-	-	nd	nd	nd	nd

+Increase; ++ Moderate Increase; +++ Drastic increase; -Decrease; -- Moderate decrease; --- Drastic decrease; 0 No change

Source: Authors

Accounts from respondents elucidate a multitude of causal factors underpinning these transformative processes. Climate change, water scarcity, and the availability and quality of pastures were reported as among the key drivers of the changes observed. Compounding drivers of change include livestock-wildlife interactions, and the encroachment of livestock corridors, propelled by growing real estate ventures and surging population growth. Similarly, the development of market infrastructures, in some of the study sites, intensifies the transformation occurring at scale, as economic dynamics reconfigure the livestock sector. Table 6 highlights the underlying drivers shaping these transformations.

Table 6. Drivers of change in livestock management systems

		Drivers of change									
Herd type	**Pattern of change**	**Agro-ecological and Environmental conditions**				**Socio-economic and demographic conditions**					
		Pasture availability and quality	Climate change	Wildlife-livestock interactions	Water for livestock (rivers, dams)	Cropping Land expansion	Real estate development	Labour shortage	Population growth	Rural infrastructure	Market infrastructures
Rainy season transhumance	Decrease	x			x	x			x		
Seasonal free-roaming	Increase	x	x	x		x		x			
Free-roaming	Increase								x	x	x
Mobile herd (camels)	Increase	x	x								
Sedentary ruminant herd	Increase	x	x	x	x	x	x		x		
Stall-fed oxen	Increase					x		x			
Dairy herding	Decrease					x			x		
Specialised farms	Increase									x	x

Source: Authors

The changing dynamics in agro-ecological and socio-economic conditions have had repercussions on livestock management requirements, influencing feeding and confinement strategies, flock size regulation, and mobility patterns. Consequently, the majority of herd types have experienced a resurgence with the exception of rainy season transhumance and dairy herding which have reduced. Herd types that inherently exhibit lesser mobility under normal circumstances have notably expanded. This encompasses, to varying degrees, seasonal free-roaming, sedentary herds, work oxen, and specialized herds. Conversely, herds characterized by greater mobility, such as rainy season transhumant herds, have declined in villages.

4.2.1 Flock size and livestock distribution

The results show that a variety of opportunities and constraints in livestock production correspond with modifications in the distribution and species diversity of herds across the communities. As illustrated in Table 5, the trends in livestock sizes exhibit a mostly heterogeneous pattern. Respondents accounts vary across villages and depending on the species under consideration, reflecting either a decrease or an increase in the population of cattle, goats, sheep, and other relevant species. In Kenya, for instance, a prevailing trend is the decline in the cattle population, as reported in FGDs. The reduction of cattle was attributed to the shrinking availability of fodder resources and an increased rate of livestock mortality due to drought. In contrast, respondents in Zambia witnessed a stark surge in cattle numbers, an observation consistently noted across all four surveyed villages of the country. Respondents affiliated cattle herd increase to better availability of inputs and genetically improved dairy and beef cattle. Improved dairy cattle were provided with supplementary feed, whereas access to abattoirs increased market access for beef production. This increase reflects the cultural values of the Tonga and Ila ethnic groups, for whom cattle ownership equates with greater social status. Cattle ownership for offspring holds a central place in livestock keepers' decisions. Conversely, different dynamics characterize the situation in Burkina Faso. In the villages of Vrassane and Cassou, there is an apparent reduction in cattle size, while respondents in Korsimoro and Mitieredougou report an increase. Reduced pasture areas, coupled with limited access to water resources shaped the changes observed in the first two villages, while growing cattle numbers were driven by increased access to market infrastructures and the increase in the number of internally displaced people (Korsimoro) and transhumant herds (Mitieredougou).

The trajectory of small ruminants, however, presents a distinct narrative altogether. As a general trend, the sheep population is experiencing growth across all surveyed villages, with the exception of Marsabit, Kenya and Vrassane, Burkina Faso. Whereas, goats have increased in numbers across all countries, with the exception of two study villages in Narok (Kenya). The results show that more households turn to these species to navigate the increasing constraints on resource availability. This propensity is particularly pronounced in Zambia, where goat keeping has emerged as a recent phenomenon, influenced in part by an NGO-led multiplication programme. Respondents further emphasised the nearly tripling of goat numbers in recent years due to their rapid reproductive rate and ease of sale, coupled with their relatively low care requirements, except in the rainy season. Conversely, in Kenya, a dominant disincentive for goat-keeping was the substantial labour demand associated with their management.

While not uniform in pace, chicken populations are on the rise across most villages. Their significance extends to both income generation and household consumption, even amongst ethnic groups that typically practice pastoralism (as is the case with the gradually sedentary Maasai from Narok). These results indicate that chickens are an increasingly pivotal component of the livestock landscape.

4.2.2 Mobility patterns and confinement strategies

Mobility patterns and confinement are among the key livestock management practices required to uphold livestock nutrition and survival by taking advantage of the spatial variation of resource availability, and to avoid crop damage. However, changes in herd composition influence and are influenced by mobility patterns and confinement strategies. The results show that significant drivers for the transformation of livestock management systems stem from the interactions between livestock mobility and movement restrictions. This situation is particularly challenging given the high reliance of the herds on natural resources. The difficulty in accessing essential resources, including water sources and grazing areas, profoundly affect the movement patterns of animals and their confinement.

In the Kenyan context, livestock mobility has reduced as a result of the fragmentation of landscapes due to land privatisation and fencing, and further intensified by growing populations. FGDs indicate that some farmers in Narok have entirely stopped the practice of dry season transhumance in place of free roaming, sometimes combined with sedentary ruminant herding. Whereas, the noticeable decline in rainy season transhumance in Burkina Faso, according to accounts from respondents, emerges as a direct outcome of livestock corridors' encroachments by cropping farms. In response to reduced mobility to pastures and water points, a substantial proportion of herders in Cassou and Vrassane downsized their cattle herds, and in some instances, relinquishing the practice entirely. This practice is now marginal, except for a few wealthy livestock keepers who contracted labour to permanently relocate their livestock to proximate villages or neighbouring countries. Hired herders sometimes travel as far as Cote d'Ivoire in pursuit of viable pastures.

A comparable narrative unfolds for dairy herding, for which mobility is restricted due to encroached corridors. Fulani herders in Vrassane and Cassou (Burkina Faso), reported splitting their herds to limit damage caused by their livestock, and circumvent conflicts with local farmers. Part of the herd is kept outside the village premises, as a result. Consequently, the number of cows available for milking purposes has reduced considerably. This problem is further exacerbated by the restricted access to cultivated fields. Traditionally, implicit rules that facilitated Fulani herders' livestock grazing on harvested farms are progressively being eroded, compelling many pastoralists to seek alternative sources of livestock feed, such as pastures. Hence, the effect emanating from the declining numbers of Fulani herders has indelibly contributed to the downward trajectory observed in the size of dairy herding within Cassou and Vrassane. As a Fulani herder explained:

> *"Nowadays, you might get in trouble, if you took your animals to graze on someone fields without their permission. It becomes more and more difficult to move around with the animals".*

(Fulani herder, In-depth interview, Cassou, Burkina Faso).

Given the challenges posed by livestock mobility constraints, livestock keepers are additionally grappling with emerging issues pertaining to the confinement of diverse livestock species. The rise in sedentary ruminant herds and seasonal free-roaming herds is a direct response to these complexities. This strategic shift was explained in terms of the varying dietary requisites of sheep, cattle, and goats, compounded by the diminishing size of grazing areas and labour availability. Consequently, these dynamics have significantly shaped the observed shifts in confinement patterns. A noteworthy change in management practices are the confinement strategies applied by livestock keepers. In Maala and Mukobela in Zambia, for example, kraals situated in the plains were initially utilised solely for confining the calves. Nevertheless, a decade ago, farmers initiated the construction of kraals in these plains to confine the entire herd. Whereas, tethering goats during the rainy season has gained prominence, particularly among women, as was revealed by participants in all FGDs. In Korsimoro (Burkina Faso), cattle are herded during the day and confined at night. However, due to water source scarcity or access restrictions, the practice of herding cattle twice a day to the homestead for watering has gained momentum in recent years.

A further complication arises from the divergent spatial locations of water sources and grazing areas. This spatial distribution restrains the simultaneous movement of different species, particularly given the long-distance travels often necessitated by cattle's distinctive feeding requirements. To address water scarcity in Zambia, some livestock keepers in Munjile are adopting measures such as digging private boreholes and wells, while livestock keepers in Itebe have begun relocating their cattle to the plains.

The labour shortage poses an additional strain on the practice of livestock husbandry, as more children enrol in schools and a substantial number of youths migrate to urban centres and artisanal mining areas (as was the case in Burkina Faso). In Narok, Kenya, there was widespread agreement that the quantity and quality of accessible schools have increased leading to the reduction of herd sizes particularly through sale for school fees and compounded by labour shortages. Whereas, in Maala and Munjile, the scarcity of family labour has prompted the practice of combining different species in one herd. A participant confirmed the trend:

"Before goats and sheep were herded separately. But my first and second born are in [the] boarding [school]. Now we are herding goats and sheep together."

(Small scale livestock keeper, In-depth interview, Munjile).

Notably, in Vrassane, Burkina Faso, the sale of common grazing areas to private investors has precipitated the reduction in the joint herding of multiple species. Single species herds are slowly supplanting combined species flocks. Consequently, herds are increasingly being divided into distinct species categories, accompanied by the resurgence of specific herd types like sedentary ruminant herds and seasonal free-roaming herds.

4.2.3 Feed and feeding strategies

The trends observed within livestock management systems are notably determined by the quantity and quality of available feed resources. An in-depth comparative analysis of all the resource maps across different timeframes reveals a stark shrinking of grazing areas, exacerbated by the depletion of feed that is both palatable and nutritionally valuable for livestock. These outcomes are attributed by respondents to various factors, including real estate expansion, public infrastructure development (e.g. schools and clinics), land sales for private agricultural endeavours, and environmental degradation.

Primarily, according to participants, the conversion of common areas into residential zones has precipitated a decline in available pastures. While local residents acknowledge the on-going urbanisation, they regret the burden it causes for livestock husbandry. Pastureland is further restrained through the sale of land plots to private investors and urban elites, who frequently enclose their acquired properties, thereby impeding livestock movement and curtailing access to hitherto communal grazing areas. This problem is particularly severe in Vrassane. Similarly, state-led projects like the construction of water reservoirs and dams, have contributed to the reduction of grazing areas, as respondents in Maala and Mukobela reported. In a contrasting account from Kenya, land fragmentation through subdivision and fencing of parcels, has led to increased free roaming (Narok) and to significantly longer distances herded to access communal grazing areas and water (Marsabit).

In addition to facing feed scarcity, livestock confront a significant threat in the form of poor pasture quality. This problem stems partly from the effects of overgrazing, weed invasion, and the indiscriminate application of chemical sprays onto cultivated fields. The uncontrolled application of herbicides, with little adherence to established guidelines, can precipitate ecological degradation, leading to the eradication of both undesirable weeds and palatable grass. Unique to the findings in Burkina Faso, chemical spraying has become a common practice, with crop farmers (including those who also rear livestock) reporting multiple sprayings throughout the rainy season. Moreover, interactions with flocks from neighbouring countries or settled livestock from displaced communities have contributed to the proliferation of unwanted grass species, as was reported in discussions in Korsimoro. In response to these emergent contingencies, livestock keepers are intensifying their utilization of feed supplements, encompassing crop residues, industrial by-products, and salt, among others.

The adopted strategies stand in stark contrast to prior practices, not only in terms of feeding timing but also in the proportion of supplementation incorporated into animal nutrition. In Burkina Faso, as early as February or March, immediately following the harvest period, livestock keepers are compelled to diversify the sources of livestock feeding. In some villages, these alternative feed sources have supplanted pastures, emerging as the principal source of livestock nutrition. In Korsimoro, crop residues have attained considerable prominence within cattle diets, especially during the dry season when daily supplementation becomes imperative. Correspondingly, respondents in Zambia have reported an increase in the utilisation of feed supplements, attributed to the adoption of stall-fed livestock practices. Similarly, in Kenya, the adoption of new sedentary livestock management practices has spurred the rise of partial supplementation.

The changing dynamics of watering practices among livestock keepers, driven by the changing availability of water resources and sources, were also mentioned as a challenge. Many now depend on pumps and wells to provide water for their livestock, often conflicting with competing domestic uses of water within the homestead. In addition to these constraints, in Kenya, over half of the multiple boreholes observed in Marsabit were not functional or with sedimented water. Moreover, the availability of shallow wells, often dug out by hand, shared by humans, livestock and wildlife provided only temporary relief to communities increasingly enduring drought conditions. Based on the host of challenges, livestock keepers across the three countries are constantly faced with making decisions on which herd types and management strategies offer the most resilient options for their livelihoods.

4.2.4 Economic function and production goals

Demand for livestock products and by-products have reshaped the economic functions fulfilled by livestock. For instance, the demand for manure to counter the decline in soil fertility has fundamentally redirected the economic purpose of livestock, thereby exerting an influence on the herd types livestock keepers raise. The proliferation of sedentary ruminant herds and seasonal free-roaming herds, while spurred by multiple drivers, is essentially a response to the diminishing soil fertility and the increased necessity to integrate crop and livestock activities. For numerous farmers, manure represents the only source for managing soil fertility. Consequently, a strategy towards limiting livestock mobility and devising confinement strategies was deemed as a viable recourse for collecting manure for crop field application. The seasonal free-roaming of cattle, and improved confinement strategies at night, also offers avenues for collecting animal faeces in dedicated spaces, including kraals, as was observed in all three countries. For herders endowed with water access and appropriate water storage equipment, manure is composted to increase its quality, as indicated by respondents in Korsimoro and Cassou.

Similarly, changes in the economic functions of livestock were discussed in Munjile and Itebe (Zambia), where respondents emphasised that the establishment of milk collection centres was instrumental in fostering greater investments in dairy herds. Whereas the introduction of abattoirs in Mukobela and Namwala also improved market access for beef cattle in Zambia. As an outcome, a notable subset of herders invested in improved breeds with enhanced milk offtake and elsewhere, meat quality. Such stark changes in economic functions were not as emphasised in Kenya, perhaps due to the long-standing existence of well-established markets in the areas visited. Nonetheless, there was recognition from respondents in Kenya that commercialisation of animals has increased across all study sites.

The emergence of market prospects has prompted numerous livestock keepers to engage in seasonal livestock fattening specifically tailored for market purposes, consequently increasing the proliferation of specialised farms within communities. In Zambia, several livestock farmers driven by business motivations have emerged, encouraged by the introduction of highly productive cattle breeds. In Itebe, cattle keeping for economic and commercial gain has surged in response to the government's introduction of a dipping fee. This policy prompted livestock keepers to shift their focus towards cattle, to earn greater income by capitalising on this service. As a consequence, the focus has shifted away from herd size as an indicator of success to income-generation as a driver of cattle-keeping. As was put by a livestock keeper in an FGD:

"Long time ago we kept cattle for prestige. In the beginning of 2000 the mindset changed and we also wanted nice houses with metal-sheets"

(Village elder, FGD, Munjile, Zambia).

Trends towards a market-oriented livestock husbandry were also seen in Burkina Faso, particularly in Korsimoro. In this village, numerous herders invest in feed supplements, concurrently applying processing techniques to enhance feed quality and absorption. In Zambia, as respondents indicated, the development of market infrastructure and the establishment of milk collection points account for the gradual progression toward commercial livestock husbandry. In villages lacking market infrastructure, the economic functions of livestock remain marginal, with the sale of livestock occurring largely to alleviate economic adversity. In the context of Kenya, the pattern presents with less pronounced clarity. The results are mixed whereby in Marsabit, households appear to be accumulating camels (in Korr) and in Narok, farmers are increasingly stocking genetically improved cattle in combination with crop production for supplementation and sometimes sale. It is however not clear about the extent to which livestock sale has drastically transformed production objectives – rather that crop sales provide supplementary income to support more sedentary practices which are characterised by short-distance transhumance at most, to free grazing at the homestead.

Likewise, changing production goals engender the growth of specific herd types. A case in point is the increasing numbers of stall-fed work oxen. This trend is a direct outcome of the expansion of cultivated plots and the reduced labour force available for agricultural tasks. As crop farmers grapple with this evolving landscape, increased reliance on oxen for land preparation emerges. The enhanced demand for cash crops, as seen in Mitieredougou (Burkina Faso), partially underpins the surge in oxen population. The advent of crossbreeds, better adapted to strenuous ploughing conditions, has facilitated the cultivation of cashew nuts on large areas of land, thereby improving farmers' incomes. In Zambia, a similar rationale underscores the introduction of goats. Their minimal resource requirements, coupled with their resilience to environmental shocks and diseases, account for the increasing prevalence of these animals across numerous villages. This trajectory positions goats as a lucrative income source, particularly beneficial for disadvantaged communities. In the contrasting context of Narok County in Kenya, sheep husbandry gradually supplants cattle rearing. Participants explained this trend by the fact that sheep graze on residual grasses and are readily marketable should financial challenges arise.

4.3 Trade-offs associated with herd management trajectories and implications for sustainable livestock production

Herd type changes reflect adjustments in management practices, such that livestock keepers either abandon, reduce or adopt certain practices to navigate drivers. These changes carry significant implications for the sector's sustainability, as some practices are closely intertwined with environmental, social, and resource governance dimensions. The sustainability dimensions included in the analysis are informed in the SAFA guidelines, namely environmental integrity, economic resilience, social well-being and good governance.

4.3.1 Environmental integrity

This category refers to the indicators that emerged from the analysis of land (soil quality and land degradation) and animal welfare (animal health and freedom from stress).[1]

[1] Topics related to greenhouse gas emissions and biodiversity are not considered, as conducting an analysis of this nature would necessitate additional measurements and assessments.

Soil fertility management

The management practices associated with each herd type affects soil fertility and health. Systems that encourage interactions between crops and livestock, such as the application of livestock manure to cultivated fields, contribute positively to enhancing soil fertility, as respondents reported. Herd types such as sedentary ruminant herds, seasonal free-roaming herds, free-roaming herds, and dairy herds are more conducive to such practices. For instance, cattle confined in kraals and sheep and goats in small huts result in the direct collection of manure through droppings. At a broader landscape level, the reduction in rainy season transhumance correlates with a decrease in animal droppings in the environment, leading to reduced soil fertility.

Conversely, the increased dependence on crop residues for livestock nutrition corresponds to reduced soil fertility, primarily due to the decreased practice of mulching. The field observations during the study indicated that a significant portion of livestock keepers actively cleared their land of crop residues, which they subsequently stockpiled for fulfilling their livestock's dietary requirements. These participants acknowledged that such a practice had adverse effects on soil fertility but justified the practice on the grounds that it prevented other individuals' livestock from grazing on their private fields. Crop residues are significant in the diets of all herd types, and particularly for stall-fed oxen and seasonal free-roaming herds according to field observations and discussions with livestock keepers. These specific herd types rely on crop residues throughout the entire year, encompassing both the rainy and dry seasons. Such reliance was particularly observed in the villages in Burkina Faso. Consequently, in scenarios where the reduction in mulching is not compensated for with sufficient amounts of manure or alternative fertilizers, the result is the depletion of vital nutrients from the soil, leading to a decline in overall soil fertility.

Land degradation and overgrazing

Interviewees highlighted that in as much as changing herd types may be a calculated response to ever increasing pressures, the strategies adopted can compromise the natural resource base upholding the integrity of the said herd type. The results show that the simultaneous prioritisation of multiple production goals can come into conflict when environmental resource availability and management practices are not adequately aligned. In Narok (Kenya), for example, livestock is kept both for culture/prestige as well as for income and nutrition, especially among the ethnic groups increasingly practicing free roaming herding with improved Sahiwal. Due to these conflicting production goals, many livestock keepers remain unwilling to voluntarily destock, despite rearing improved animals that require greater inputs while often having insufficient resources for their nutritional upkeep. As a result, overgrazing was frequently observed and particularly pronounced in the lowland areas of Narok where grass is already limited and supplements are not readily available or affordable. This seeming conundrum meant that farmers often had more animals than the carrying capacity of their land. Similarly, respondents in Zambia recognised the increasing rate of overgrazed pastures, which was verified through observations. As one interviewee emphasised:

> *“More cattle eat more grass and the high grass consumption leads to overgrazing in the plains”* (Extension officer, EXI Mukobela)

There has been an NGO effort to mitigate overgrazing through a rangeland management intervention in Maala and Mukobela (Zambia) in 2019. However, the program was reportedly unsuccessful due to the unsupervised nature of seasonal free roaming herds during the day and the absence of finance for fencing common lands. Another barrier to success was identified as seasonal flooding that destroys temporary and unmaintained fences.

Changes in species diversity of herds was additionally identified as a leading contributor to overgrazing. For instance, in Kenya, the results show that sheep numbers are steadily increasing and herded under free roaming or sedentary ruminant practices. Even though sheep require a smaller volume of grass, they graze the grass very close to the ground, making it difficult or even impossible for plant biomass to recover. As observed in Narok in particular, overgrazing leaves large swathes of bare soil vulnerable to wind erosion or to harmful invasive weeds. At the landscape and individual level, the results indicate that while transitions to new livestock management system may in the short term provide more profits and even prestige, environmental sustainability in the long term may be compromised if strategic decisions on herd composition and flock size are not factored into productivity planning.

Animal welfare

As livestock keepers adapt their feeding and watering strategies to cope with pressures, this often directly modifies their practices related to animal confinement, flock size regulation, and mobility patterns. The extent to which livestock health and freedom from stress are affected was reported variably across the study countries. Such changes, particularly the rise in seasonal free-roaming practices and sedentary livestock management, have led to the tethering or confinement of animals for extended periods, often in suboptimal conditions. Such dynamics raised concerns amongst respondents about the welfare and health of the animals, as indicated by reports of increased stress and discomfort, especially during the rainy season. A livestock keeper from Burkina Faso expressed this sentiment, saying:

"*They do not like it when the place is rainy*, *it makes them feel uncomfortable.*"
(Livestock keeper, in-depth interview, Vrassane, Burkina Faso)

Similarly, in Munjile, livestock keepers reported that sheep and goats were kept together during the rainy season, and herded for a few hours daily. These herding and confinement patterns were further corroborated through participant observations. In the same vein, findings emerged from the examination of cattle housed in kraals in Korsimoro (Burkina Faso), where the animals were frequently subjected to damp conditions, often for extended hours. Subsequent FGDs revealed that many livestock diseases, like foot-and-mouth and Brucellosis, could be attributed to this confinement practice, which significantly compromised the overall resilience of the livestock herd. Therefore, the increase in herd types like sedentary herds and seasonal free-roaming herds can cause livestock diseases, with potential consequences for mortality rates and livestock productivity.

Increased likelihood of various diseases also emerged with respect to free roaming herd types in the study sites. In Zambia, a higher tick density was mentioned by participants as a growing challenge to livestock resilience. Whereas, free roaming practices in Narok (Kenya) also exposed livestock to increased human-wildlife interactions on the boundaries of the Maasai Mara National Reserve. Respondents indicated that if uncontrolled, not only do the chances of livestock predation increase, but so too does the susceptibility of animals to contracting diseases carried by wildlife, such as the fatal malignant catarrhal fever. Another challenge associated with livestock health relates to the increased herds of free roaming peri-urban livestock. In the case of Kenya, the consumption of indiscriminately disposed plastic waste by free roaming livestock was observed in urban areas. Ingesting such materials may lead to severe discomfort of livestock from damage to the digestive system. In the long term, the accumulation of foreign material in livestock can, amongst other health threats, lead to intestinal blockages.

Inadequate dietary provisions for the animals was often cited as a limitation to livestock productivity. This problem stems from the limited availability of resources and the poor quality and quantity of available feed, as well as the watering practices employed. This situation significantly affects transhumant herds, mobile herds, and seasonal free-roaming herds. The health and welfare of livestock can be considerably jeopardised based on whether their diet is primarily composed of pasture, supplementary sources, or a combination of both. This issue becomes especially acute during the dry season when feed resources become scarce. Herds that predominantly depend on either type of feed can face challenges when the growth in herd sizes is not matched by an equivalent increase in available feed resources. Overall, livestock keepers recognised that they give minimal quantities of feed to their animals, sufficient to ensure survival but insufficient to meet daily livestock nutritional requirements. As a herder indicated in the FGD in Cassou:

“*Sometimes you look at your animals, you see that they are not well-fed but there is nothing you can do about it”*

(Livestock keeper, FGD, Cassou)

Additionally, livestock welfare may come under threat in areas grappling with water scarcity. Participants were aware of the limitations for livestock under conditions of inadequate water quality and quantity:

"*We do not even have enough water for ourselves, let alone for the animals. We only give them something so they don't die of thirst, but you cannot say that is enough*"

(Livestock keeper, In-depth interview, Cassou)

A strategy often observed to enhance the livestock production portfolio was to reconfigure herd types by stocking more productive, improved animals. However, the results show that the introduction of herd types that are not well adapted to the existing production system also raised animal welfare issues amongst respondents. For instance, results show the widespread transition towards dairy cattle specialisation with Jersey and Friesian crosses in Zambia. However, unlike local breeds that are resilient to current stressors, the differential feed and health requirements of improved breeds require the corresponding management practices from farmers. However, this was sometimes not the case and served to undermine animal welfare especially if farmers managed improved cattle using traditional free-range management for local breeds. The following statement provides a description of a fateful outcome:

"Out of 18 Friesian cattle my husband is remaining with 2 cattle"

(Wife of a small-scale farmer, Mukobela)

4.3.2 Economic resilience

This category refers largely to the indicator of investment (profitability) which emerged most prominently from the study.

Herd types and income generation

Modifying their livestock management approaches to capitalise on market opportunities has enabled livestock keepers to enhance productivity and expand their economic returns. The interviews conducted across all villages suggested an increase in income generating opportunities derived from livestock production, primarily attributed to improved access to market resources, milk collection centres and abattoirs. This trend was corroborated during FGDs, with a majority of participants emphasising that income generation now stands as a primary motivation for livestock keeping, diverging from previous years when livestock were primarily held for prestige. Despite the elevated costs associated with the greater integration of feed supplements into livestock diets, livestock herders reported a net benefit. In Korsimoro, in particular, the presence of a livestock market allows farmers command better prices, as they highlighted:

"*With more buyers, you have the opportunity to bargain and get a fairer price than if you had to use the services of an intermediary. Besides, with a close market,* *unless there is urgent need for money, you can take back your animal if the price proposed does not meet your expectations*".

(Livestock keeper, FGD, Korsimoro).

The increase in specialised farms is, thus a result of the enhanced increase and the access to better prices, enhanced feeding strategies and fattening practices. Similarly, the introduction of milk collection centres in three villages in Zambia (with the exception of Maala), has spurred increased investment in dairy herds, fostering income gains for livestock keepers. This phenomenon was marked by the emergence of improved breeds, signalling a significant shift in the landscape.

At community and village level, the development of livestock and the increased consumption of livestock feed has translated into the development of, albeit weak, feed markets. This has led to increased income generating opportunities for traders and for households that have small herds size allowing them to generate surplus feed for sale. Markets for feed supplements have sprung around villagers in Korsimoro and Vrassane (Burkina Faso), with people gathering fresh grass for sale. Crop farmers with limited numbers of livestock also engage in the sale of crop residues, increasing their income sources.

4.3.3 Social well-being

This category refers to the indicators of equity (gender equality) and cultural diversity (indigenous knowledge).[2]

Gender equality and demand for household labour

The changes in livestock practices have equally had implications for labour and time use within households. This is particularly relevant for water resources for livestock keeping. In all villages, there were reports of reduction in access to water. During a visit to a water pan situated on the outskirts of Suswa (in Narok), respondents reported that it took them days to reach their destination, due to the increased distance:

[2] The majority of indicators (such as employment relations, safety of workplace, operations and facilities) were not directly relevant for the study respondents within the context of smallholder livestock production.

“*I have been travelling on foot with my herd for four days and have lost two young cattle along the way… but this is the closest water point*.”

(Herder, Suswa, Narok)

The increase in the number of sedentary herds, and seasonal free-roaming herds, increases the burden of water collection for some categories of the household members. The growing demand for water, coupled with the added care required to accommodate the diversity of herd types, has significantly increased the burden particularly on women within the different communities. In addition to their usual responsibilities of procuring water for household chores and domestic use, women gradually bear the additional task of sourcing water for livestock, increasing their trips three-fold to get the resource. This sentiment was expressed during all FGDs with women in Burkina Faso. In villages like Cassou and Korsimoro, the duty of water collection further translated into greater financial responsibility for women. The 100 CFA paid for a barrel of water is often borne by women, as they declared in the FGDs in Cassou and Korsimoro. Men typically bear the responsibility of covering the annual water fee for the utilisation of public water sources and pumps. However, it is noteworthy that women frequently find themselves having to pay for the water they collect to fulfil household chores, which includes water designated for livestock consumption. As a woman in Cassou declared:

“*Even if you ask your husband to pay back the money you have used to buy the water, he will not return it. So, you just end up doing it without any expectations*”

(FGD, Cassou)

Whereas in Marsabit, women are increasingly involved with the management of resources for livestock due to increased sedentarisation and the absence of male family members (rural – urban migration). As most households do not own draught animals, payment for private transport despite other financial commitments is a challenging necessity. It was observed that women make multiple trips on foot to fetch water in jerry cans to meet household and livestock needs. With fewer children available to provide additional labour during the school term, women are often burdened with this additional labour.

Cultural diversity and indigenous knowledge

Changing herd types, as indicated from the results are driven both by adaptation to crises, and also in response to economic opportunities. Examples of these herd types include the specialisation to dairy cattle in Zambia and the transition to mixed-crop livestock farming in Kenya - both of which depend on seasonal free roaming. In some contexts, the increased drive towards commercialisation worsened by changing land tenure practices, has led to concerns from respondents about the erosion of traditional ways of life. For example, in Kenya, the loss of culture and tradition emerged as a concern amongst respondents interviewed in Narok. A negative response was received when interviewees were asked about whether land subdivision affects livestock management. The response emphasised a disruption to the Maasai way of life. The following statement reflect this sentiment:

"We used to share the land and roam freely with our cattle, but now we cannot do that…"

(Interviewee at Narok livestock market)

Concerns regarding commercialisation and 'for-profit' livestock production also elicited strong reactions from a different respondent. Moreover, a profound contribution from respondents regards the influence of livestock and markets on traditional livestock-keeping values and practices increasingly emerging as a result of generational change, as seen here:

"Our children are being lured by the promise of wealth and luxury. They are being pressured to sell their land and move into the cities. Fewer and fewer are returning home to take over the farm and carry on our [livestock-based] traditions."

(Maasai elder, Narok)

While these concerns were not widely expressed in the study sites, that latter regarding generational change is noteworthy. This is especially the case because across all sites, the phenomenon of rural outmigration accompanied by increased proportion of school going children does have immense implications for the application of indigenous knowledge and practices and how herd types will evolve in the future regarding management, viability and overall sustainability.

4.3.4 Governance

This category refers to the indicators of participation (conflict resolution and stakeholder engagement) that emerged from discussions.

Conflict over resources

The governance of resources required for adequate livestock management is under pressure from multiple sources such as land privatisation, fragmentation, real estate development and other forms of encroachment observed from the results. The consequent transitions of herd types which are both deliberate or unintended, are therefore testament to these already scarce and diminishing resources including water. However, only in few cases were there concrete examples of conflicts over resources, which is surprising given that at least two of the study countries are experiencing pockets of different forms of ongoing insecurity, compounded by prolonged drought episodes. However, the results do show disputes at farmer and landscape levels, where farmers with more animals need more resources. In Zambia, encroachment of crop farmers into grazing areas caused considerable tensions among community members. At the household level, dairy farmers complained about the water demand of improved dairy breeds in Itebe which increased water use conflicts between home and animal water needs, calling for more boreholes to be dug in the area. Other forms of conflict were reported in Zambia and included theft whereby respondents from every FGD and nearly all household interviewees identified that they had experienced livestock theft. According to one commercial farmer, approximately 30% of livestock is stolen from Namwala and in Maala, the high rate of theft even led to the closure of the abattoir.

Stakeholder engagement and effective participation

The extent to which the needs of livestock keepers are integrated into development and spatial planning has considerable implications for the design and durability of physical interventions. Across all countries, the topic of social inequality repeatedly emerged either in relation to land acquisition by elites or the weak provision of government services. Concerns about inequality were also expressed in terms of development approaches and the exclusion of livestock keepers. For example, according to an expert interviewee from Zambia, dependency culture poses a considerable risk to sustainable development of livestock areas and in some cases, government approaches may also compromise successes. An example was provided whereby the government constructed a borehole in Itebe in 2008 without stakeholder dialogue as compared to the stakeholder dialogues held with communities who were beneficiaries of the milk collection centre. It is unclear however if the borehole was functioning to full capacity at the time of data collection. As the economic value of livestock grows, so do concerns as to whether those who depend on livestock the most will be meaningfully engaged in the development of the sector.

5. Discussion

This section reflects on the study approach and findings within the context of exploring possibilities of sustainable livestock development pathways.

5.1 Classifying livestock systems: livestock management systems as a novel and consolidated approach

Amongst sector stakeholders, there is consensus that livestock production in Africa plays a crucial role for the environmental, economic and socio-cultural development of the continent. However, the future direction of livestock production is unclear given the multiple competing players and their concerns regarding positive and negative implications for livestock keepers, their animals and natural resources that sustain all livelihoods. Because the conditions under which livestock are reared are diverse and dynamic, classifying production systems into manageable 'fit for purpose' typologies is among the primary steps for beginning to engage with the underlying concerns shaping the sector.

Consequently, the formulation and development of classification systems has been elevated over the years. The fundamental endeavour of livestock classification has evolved from the well-established classifications that distinguish between broad, and often global categories of animal production (e.g. range livestock vs crop-livestock; livestock only, rainfed/irrigated crop-livestock and industrial) to encompassing typologies that integrate human population density (Thornton et al, 2002; Kruska et al, 2003), cattle density (Wint et al, 1999), the quality and source of feed inputs (IIASA FAO), animal feeding operations (Derner et al, 2017), degree of commercialisation (Teufel et al, 2010), and more comprehensively, land, labour and capital (FAO, 2018). The benchmark classification systems (such as Seré and Steinfeld, 1996; Jahnke, 1982; Steinfeld and Maki-Hokkonen, 2017) continue to contribute extensively to the mapping and understanding of livestock at both the global and African scale.

To accompany the growing portfolio of classifications, this study adopted a more ‘bottom up’ approach than some of its predecessors with the expectation of shedding new and/or supporting emerging insights on livestock production systems in Africa from the ground, up. This approach diverges somewhat from the growing number of classification systems that tend to include variables targeted to a specific focus. For example, classifications that characterise production systems for purposes of breeding and productivity improvement (Taye et al, 2016; Rege, 1993; Tadesse et al, 2005), species specific classifications for systemic understanding of population dynamics (Otte and Chilonda, 2003; Fernández-Rivera et al, 2004), classifications for targeted farm extension and advice (Ahikiriza et al, 2021) as well as classifications that focus on farmer-oriented perspectives to enhance market access (Ramsey , 2009; Tadesse et al, 2015). Only few recent classifications focus on household level characteristics at a localised scale (De Glanville et al, 2020), while even fewer focus on the herd level (Brock et al, 2021 focus on disease control and surveillance activities - although not in the African context).

In contrast, the classification presented here provides a unique contribution by encompassing a smaller unit of analysis – the livestock management system – which is embedded as the fundamental component of all livestock systems. The introduction of an alternative, but complementary terminology to describe livestock practices is revealed through detailed descriptions of practices that make up mobile, seasonal and free roaming herds; sedentary ruminant and dairy herds; dry and rainy seasonal transhumance herds, dairy herding and pastoral work oxen. The categories are not entirely mutually exclusive, however exhibit important and often neglected nuances within and between the various agro-ecological zones. Moreover, the approach reveals the complexities of livestock management practices in systems that do not always neatly overlay onto existing classifications (e.g. peri-urban livestock production embedded in systems with communal land tenure or mixed-crop livestock systems nestled in semi-arid environments). The deep dive into the livestock management systems here does not however divert from the broader classification systems, nor does it attempt replace existing targeted classifications. Instead this classification presents a combination of variables that determine with finer detail the diverse herding practices that exist in the selected sites and can be used to complement the more targeted classifications to allow for holistic outcomes.

5.2 Drivers of change: Harmonising findings

In accordance with other studies (Eeswaran et al., 2022; Malabo Montpellier Panel, 2020; FAO, 2018a; FAO and OECD, 2023; FAO, 2018b; Vall et al, 2021), the results illustrate that livestock keepers in sub-Saharan Africa face multiple pressures including natural resource constraints with water and pasture, land use change and encroachment of cropping land, population growth and resource use conflicts. Concurrently, livestock keepers are also encountering economic, institutional and social opportunities that influence changing herd management strategies. The response to the drivers reveals two main trends which can be mapped along a livestock management system spectrum from transition to transformation. On one end of the spectrum, farmers who transitioned, changed their herd composition but maintained their existing livestock management systems. For example, livestock keepers in Kenya continued to practice dry season transhumance but transitioned from jointly herding sheep, goats and cattle, to herding sheep and goats and/or cattle alone. Livestock keepers in Marsabit, Kenya maintained a mobile herd, but species composition transitioned towards stocking camels which in some cases replaced cattle. Whereas, in Zambia, sedentary ruminant herding became increasingly associated with goat husbandry; and seasonal free roaming with new cattle species was also observed.

On the other end of the spectrum, farmers who exhibited transformations, shifted their herding practices entirely towards new systems. For example, in Cassou, Burkina Faso the results illustrated that farmers gradually reduced their cattle herds in some cases totally abandoning rainy seasonal transhumance – signalling a shift to a sedentary ruminant herding system. A transformation to to free roaming and sedentary ruminant herding was also observed in Narok, Kenya.

Overall, the results generated on the current systems do complement existing studies across various aspects regarding livestock dynamics, drivers and trends. On the one hand, the results on herd type and herd composition (e.g. dominance of seasonal free roaming with sheep alone and sheep and goats) support existing studies, which indicate the growth of small ruminant populations across the continent (e.g. FAOSTAT). Regarding country-specific changes in herding practices, the results corroborate findings that show a shift toward more climate resilient livestock species such as camels in Kenya (Watson et al, 2016) and goats Zambia (Loison and Hillbom, 2020); the dominance of dairy cattle herding amongst Fulani in Sudanian and semi-arid regions of Burkina Faso (Pfeifer et al, 2021) and widespread practice of free and seasonal free roaming of most livestock species in Zambia (Odubote, 2022).

On the other hand, within the context of a classification system, the results shed light on understanding the species combination and practices under each type of herd category. Where official statistics tend to only focus on individual species, the livestock management systems approach offers an integrated perspective that captures trends in species composition and associated drivers. Many studies primarily provide information on trends in individual livestock species rather than a focus on the changing dynamics of herd composition (with some exceptions, namely, Zampaligre´et al, 2014; Catley et al, 2016). Understanding these changing dynamics provides insights into implications for the future sustainability of livestock production. For example, understanding herd composition, in the case of seasonal free roaming offers implications not only for labour and land degradation, but also for herd biodiversity. A herd with different livestock species combinations allows livestock keepers to benefit from the diverse livestock traits as well as to more effectively manage the risk from diseases and droughts across the species (Simpkin et al, 2020). However, the trend towards single species herds as observed in various study sites may be potentially problematic as adverse drivers continue to intensify into the future. The findings also diverge slightly from the typical understanding that cattle and to a lesser extent sheep, are more likely to be herded throughout the year (Turner and Hiernaux, 2008).

5.3 Livestock transitions, policies and sustainable livestock development

In light of the pressures and opportunities facing livestock production in the study sites, classification systems that adequately characterise change are required. The study highlights modifications in the ways of rearing livestock such as changing the herd composition with new breeds (for example, cross bred Sahiwal in Kenya), removing or splitting herds for some species (such as goats in Kenya and cattle in Burkina Faso); and the diversification of livelihood portfolios away from livestock only production and toward mixed livestock and crop agriculture (as was observed in Kenya and Zambia). Therefore, there is a need for dynamic approaches that enable investigation of livestock system developments in the future with respect to responses to drivers including population increase and land use change, demand for livestock (and crop) products as well as environmental and climate changes (Robinson et al, 2011). Moreover, an exploration of current characteristics of livestock production and the classification of herds can contribute to the design of programmes compatible with systems that support a range of livestock-based livelihoods. Multifaceted classification models provide a basis for monitoring system transitions and a localised basis for evaluating capacity to mitigate, cope with, recover from and adapt to the impacts of existing and upcoming environmental, climate and disease-related and socio-economic shocks (de Granville et al, 2020). The similarities and differences across the study sites can inform interventions and targeting at different scales in order to adequately reflect the opportunities available to and challenges facing the different systems observed.

The study reveals that a number of conflicting factors contribute to changes in herd management practices. Of note is the expansion of residential zones to accommodate population growth which reduces available pastures; the privatisation and fragmentation of land which constricts mobility; and, the increased demand and availability of education which drives to labour shortages, encourages rural exodus and intensifies gender inequalities. These findings imply the need for policies that are robust, yet flexible enough to reconcile competing interests. Understanding these transitions and transformations provide an entry point for informing local level initiatives that accommodate for sustainable production amidst complex drivers. This may include, for example, coupling mobile herds with mobile education, or creating land use corridors through reviving local institutions to ensure that livestock keepers can meet household and sector-based needs. To facilitate sustainable transitions within the livestock industry, it is imperative to establish comprehensive and coherent policy frameworks. This necessitates a profound comprehension of the intricate dynamics and contradictions inherent to livestock systems and an acute awareness of potential feedback loops that may exacerbate the suboptimal performance and sustainability of these systems. The findings of this research further underscore the incongruence of livestock intensification initiatives with global sustainability objectives, thereby emphasising the imperative for policymakers to exercise awareness in formulating and implementing livestock policies that are congruent with seemingly conflicting drivers of change.

In particular, the results illuminate the necessity for land tenure reforms which may include land use plans to support the transformations underway within livestock systems. The encroachment of livestock corridors, as elucidated in the findings, serves as a stark indicator of the limitations in policymakers' ability to enforce the rules and regulations governing land usage. To varying degrees, the political economy of livestock systems still favours crop farmers at the expense of livestock keepers, whose voices and needs are frequently marginalised in economic decision-making processes (Namonje-Kapembwa et al, 2019; Dutilly et al, 2021). Furthermore, endeavours to intensify livestock production often disregard pastoralists, whose livelihoods hinge upon livestock herding and the pursuit of suitable grazing lands. As crop farmers delve into livestock husbandry, the pivotal role of pastoralists within the overall ecosystem is underestimated, and their presence in farming communities becomes a source of constraint and potential conflict.

Consequently, the development of livestock cannot be pursued without a comprehensive understanding of the intricate interplay among livestock systems at various scales. The envisaged reforms must incorporate the interests of both crop and mixed-crop farmers and pastoralists, whose sustenance relies on access to shared resources and the freedom to move in diverse landscapes. The delineation of livestock corridors based on joint land-use plans and the promotion of collective action has the potential to effectively govern the management of these resources. Policies should therefore strive to engage all stakeholders and users of common resources in defining and implementing resource governance plans. In this sense, adopting the livestock management systems approach to guide the design of interventions would further highlight recognition that investigations at a more localised scale across similar agroecological zones are imperative to avoid blanket interventions that assume uniformity of livestock production due to the overdependence on the similarities in agroecological zones.

Overall, for the livestock revolution to thrive, sustainably, the role of market infrastructures which are crucial to the development of a robust economy must not be overlooked. The results, especially from Zambia and Burkina Faso demonstrate the considerable role of markets for changing herd composition and production objectives to meet growing demands for live animals and products, Consequently, fostering the growth of livestock systems in this regard necessitates substantial investment in infrastructural development to create the appropriate incentives for livestock keepers to embrace innovative practices. Such policies should particularly be complemented by initiatives aimed at enhancing the availability of livestock feed. Indeed, the research underscores the significance of addressing issues related to feed accessibility and availability as a major impediment to livestock husbandry. Enhancing this sector holds the potential to offer a diverse array of feed options while simultaneously fostering job creation, particularly among the youth, whose interest in agriculture has experienced a decline.

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