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# From the herd's perspective: Rethinking livestock classification systems

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# From the herd's perspective: Rethinking livestock classification systems

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## Abstract

The farming systems approach has emerged as unique tool to deal with the enormous diversity of smallholder farming in the tropics. However, the focus was mostly placed on the cropping component of farming systems. In 1996, Seré and Steinfeld devised a global classification, which remains an important basis for classifying livestock farming systems. Although this classification system has been useful at global scale, its application at local level results in a few and rather broad categories of livestock farms. Such farms may not necessarily be similar regarding their size, resource base, enterprise patterns, household livelihoods and constraints.

To address this limitation, we analyse the existing farming systems classification and propose a new approach that complements such farm level classifications with a classification of livestock management practices at herd level. We define the *livestock management system* as a typical combination of herd structure, feeding, and herd management, and their interlinkages. We applied an iterative process of reviewing, coding and classifying primary studies about livestock in Sub-Saharan Africa. The following main classification criteria were thus developed: main feed source, production goal, how animals are confined, and - if applicable - the mobility pattern. On this basis we identified 12 distinct livestock management systems.

For empirical application, we use data from 3 sites in ILRI's IMPACTLite dataset, that fall into the category rainfed mixed farming systems in arid/semi-arid tropics and sub-tropics (MRA) according to Seré and Steinfeld. However, we identify distinct 3 livestock management systems, that are practices across these locations. These 3 systems describe the management practices of over 90% of animals in the datasets.

By focussing on livestock management practices on herd level (rather than the household level). Our approach can support researchers and development practitioners in collecting high-quality data, developing better data structures, understanding livestock production systems, assessing change in livestock management and guide more targeted interventions.

## Key Words

Livestock development, Systems analysis, Classification, Animal Improvement, Husbandry, Flock, Tropical

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# 1. Introduction

Livestock development needs to address multiple, potentially conflicting goals: It should provide viable incomes for livestock keepers. This regard both livestock farmers incomes and wages, as extreme poverty is especially prevalent in agricultural wage labourers and pastoralists (FAO, 2019). Furthermore, in the face of increasing resource competition, livestock management is often entangled in local power struggles around land use practices and tenure politics, that may escalate into violent conflict between farmers, herders and other armed groups (Brottem, 2020). To safeguard the global climate and biodiversity, livestock related greenhouse gas emissions and feed-related land-use change need to be reverted (IPCC, 2022).

The farming systems approach has become a key tool to describe and analyse the complexity and diversity of smallholder farming in the tropics. Following the pioneering work of scholars such as Hans Ruthenberg (1971) and Pierre de Schlippé (1956), the approach has been further developed - most notably under the leadership of FAO. Unfortunately, there has been relatively little research on classifying, mapping and analysing livestock farming systems in Africa since the influential books of Hans Jahnke (1982) and Carlos Seré and Henning Steinfeld in 1996. The focus has mostly been placed on the cropping component of farming systems (see e.g. the classifications by Dixon, Gulliver and Gibbon, 2001; Dixon et al., 2019).

Carlos Seré and Henning Steinfeld' s classifiction (Seré and Steinfeld, 1996) remains an important basis for classifying livestock farming systems. The classification relates to the farm level starting by separating livestock production systems (LPS) into systems solely based on livestock and systems mixing crop and livestock farming. The second level of classification includes grassland based LPS, landless LPS, rainfed LPS and irrigated LPS. These are then split according to 3 agroecological zones[1] or in the case of landless LPS into ruminants vs. monogastric. The classification's global scope results in few rather broad categories of farms, which are not necessarily similar regarding their size, resource base, enterprise patterns, household livelihoods and constraints. For example, smallholder rice-buffalo systems in southeast Asia and large-scale commercial soybean-maize-pasture operations in Brazil are both classified as "mixed rainfed in humid/subhumid tropics" (ibid, p. 26). This makes this classification less useful for tracking changes in livestock management practices and designing customized livestock interventions.

[1] temperate zones and tropical highlands, humid and sub-humid tropics and sub-tropics; and arid and semi-arid tropics and sub-tropics

In this paper, we propose a new approach that complements existing classifications. In addition to classifying the production system of farms (like Seré and Steinfeld, 1996), we suggest a classification of herds based on management practices. Each livestock management system is defined by a distinct combination of management practices, particularly with regard to the main feed source, production goal, how animals are confined, and - if applicable - the mobility pattern. A livestock farming system can then be described as a combination of (multiple) herd/flock systems as well as cropping systems. This modular approach addresses the need for meaningful descriptions of livestock and herd management practices on the one hand, and farm level analysis on the other. The classification relates to the management of chicken, pigs, sheep, goats and cattle. While the classification approach has global relevance, we chose Sub-Saharan Africa as a case study to demonstrate its application.

## 2. Proposed classification

### 2.1. What is a livestock management system?

The proposed classification is based on an agrarian systems approach, which combines the analysis of systems on different scales (see Figure 1). The basic level consists of herd/flock systems as well as cropping systems[2]. We define the *livestock management system* as a typical combination of herd structure, feeding, and herd management, and their interlinkages. The herds' particular herding and confinement practices, feeding strategies, crop livestock interactions, mobility patterns and production goals are interdependent and thus form a management system on the herd level. Herds that fall into the same livestock management system category typically face similar challenges and can be targeted by similar interventions and development strategies. The concept also builds upon pastoralists own conceptualizations whose languages often include terms to describe different types of herds (see e.g. box 1)

A combination of cropping and livestock management systems forms a system on the level of the farm, the *farming system*. When the household as a whole is considered, including reproductive and non-farm activities, one speaks of an

[2] C*ropping systems* follow the idea of de Schlippé's field type, which is "a structural concept: it covers the combination of a certain number of plants cultivated either as mixed cropping when sowing periods are simultaneous or successive, either in succession during the same season, or still in mixed sequence. Furthermore, it relies on a specific ecological context and, thirdly, it is characterised by a specific cultivation method which is a function of a specific farmwork planning" (de Schlippe, 1956 in Cochet, 2015 p. 46; Cochet, 2015, pp.38–52).

*activities system*. Lastly, the *agrarian system* consists of the different kinds of farming systems present in an area, as well as the social relations in which they are involved (Cochet, 2015, pp.38–52).

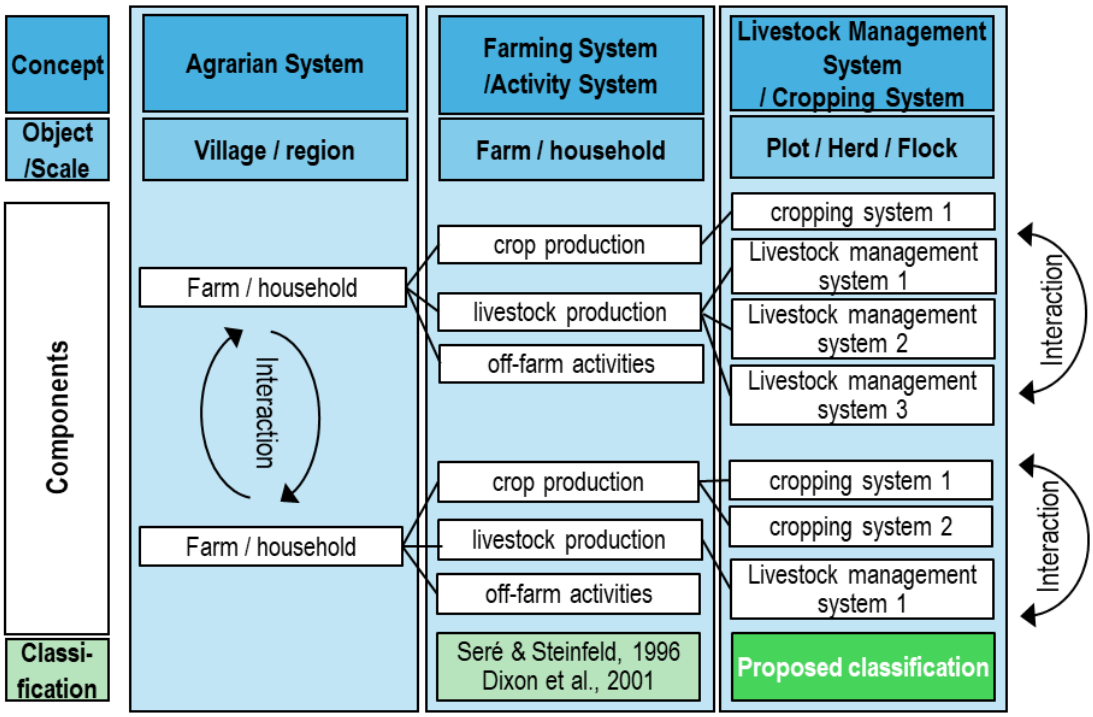



**Figure 1. Theoretical framework; adapted from Cochet (2015, p. 38-52)**

## 2.2. How we classified livestock management systems

We used an iterative process to identify livestock management systems commonly practiced in Sub-Saharan Africa: Firstly, a list of classification criteria was developed based on our understanding and classic literature (especially Jahnke, 1982). Secondly, journal articles and PhD theses on livestock farming systems in Africa were coded according to these classification criteria. Available information, e.g. the type of feed used, was transferred to a spreadsheet, where each herd described in the literature would represent one line. After coding the first articles, the classification criteria was revaluated and adjusted. Lastly, we used the table of coded articles to establish common herd management systems; i.e. common combinations of values in the classification criteria. These management systems were described, while rereading the articles describing a system to doublecheck for inconsistencies.

### 2.2.1. Categorization criteria

Table 1 shows the characteristics used to describe the herd / flock systems. While some variables clearly focus on the herd level (feed, confinement, stock reproduction, flock size), others make linkages to the farming and activities system (farm-level crop livestock
interactions, economic function) and the agrarian system (land, labour, market-based crop-
livestock interactions). While the variables are presented as categorical, the boundaries between values are not always clear cut; e.g. when a farmer keeps an eye on her goats while doing domestics chores the boundaries between herding and free roaming get blurred.

As we aim to classify the livestock management systems present in Africa, the variables used in categorization are those that describe the herd level. In the following we explain the paramount relevance of the chosen criteria:

1. The main feed source is a key criterion of distinction. It is linked closely to method of confinement and to production intensity. Natural vegetation (pasture and browse) and a combination of crop residues and fodder crops are most common. Commercial feeds and processing by-products (e.g. cotton seed) are mainly used in specialized farms like layer or broiler farms.
2. How animals are confined during the day, does not only determine the daily workflow in the husbandry of the herd – it

**Table 1: Characteristics used to classify and categorize livestock systems**

| Variables | values |
|---|---|
| Feed | concentrates<br>Mineral supplements<br>fodder crops<br>crop residues<br>processing by-products<br>kitchen scraps<br>pasture or rangelands |
| Confinement of animals (day) by season | stable<br>herding<br>tethering<br>free roaming<br>fences |
| Confinement of animals (night) | stable / share house with people<br>kraal<br>fence<br>herding<br>tethering<br>free roaming |
| Crop-livestock interactions | use of urine/solid excreta<br>animal droppings<br>fodder cropping<br>crop residues (feed)<br>crop residues (grazing)<br>animal traction |
| Stock reproduction | uncontrolled mating<br>controlled mating<br>artificial insemination<br>buying stock |
| Labour | usually owner tends animals<br>(extended) family<br>hired animal tenders |
| Land | private (owned/allocated)<br>private (delegated rights)<br>commons |
| Production goal | meat<br>milk<br>eggs<br>offspring<br>labour<br>other animal products |
| Economic function | home consumption<br>income<br>gifts<br>ceremonial use<br>paying labourers<br>accumulation<br>selling in crises<br>crop-livestock interaction |
| Flock size | number<br>Herd sructure<br>Other livestock owned |
| Mobility | daily grazing mobility<br>sattelite camps<br>wet season transhumance<br>dry season transhumance<br>none |

also co-determines other key characteristics like feed and potential methods of stock reproduction. It therefore serves as the first characteristic. We distinguish between wet and dry season as practices can vary between seasons.

3. Another key feature is the production goal. Beyond meat, milk and labour, we have included the category 'offspring', when reproduction is a key goal of the livestock management system. Even when this is not the commodity sold or consumed, it is important to note, whether farmers are interested in fertility rates or e.g. meat growth.
4. For herded livestock that is kept for reproduction, we also distinguish the mobility pattern. Grazing mobility means livestock is herded to pastures during the day, but the animals return to a home settlement in the evening. In contrast, travel mobility means that new camps are established throughout the season. This concerns both satellite camps close (10-50 km) to the home location, where part of the herd temporarily stays, e.g. at lowland dry season grazing areas – and transhumance, where the herd moves over large distances to exploit a spatial gradient like (altitude, latitude, retreating floodplains) that outweighs the energy requirement of movement (Turner and Schlecht, 2019).

### 2.2.2. Livestock management system categories

***Free roaming*** is simultaneously one of the most widespread and most scientifically neglected livestock management system in Africa (e.g. Jahnke, 1982 dedicates only 1 paragraph in a 254 page book). Stock are let free in the morning to roam around unsupervised and graze on grasslands or crop residues, but may be supplemented with some kitchen scraps or crop residues (Gondwe and Wollny, 2007; Thys et al., 2016). In this low-intensity system, breeding offspring is the main production goal with eggs e.g. being mostly left to hatch not consumed (Kondombo et al., 2003; Mtileni et al., 2012; Harpal Singh, 2015) – making fertility and mortality the main concern in the system. The animals serve as a capital stock to be sold when cash is needed or as a pay for seasonal labour. Furthermore they are slaughtered for festivities and ceremonies (Gondwe and Wollny, 2007; Lawal, 2011; Thys et al., 2016). Thus, free roaming stocks play a key role in ensuring the resilience of rural households. The system is used for chicken, sheep, goats, pigs and cattle, where stock can roam freely without causing crop damage (Armbruster and Peters, 1993; 146 Adriansen, 2002; Lakew, Melesse and Banerjee, 2017) and where the threat from predators and theft is low (Adriansen, 2006).

***Seasonal free roaming*** can roam freely during the dry season but need more confinement during the rainy season to avoid crop damage. This particularly applies to cattle and a lesser extent sheep, which are more likely to be herded throughout the year than goats (Turner and Hiernaux, 2008). During the rainy season animals may be herded, tethered or kept in

a stable (Kagira et al., 2010; Siegmund-Schultze et al., 2012; Urgessa et al., 2012; Tindano et al., 2015). As in the free roaming system, interventions would focus on fertility and mortality to enhance the livestock's crucial function in household resilience.

***Dairy herding*** is a livestock management system many pastoralists who manage multiple herds will identify; e.g. the Borana as *haawicha* (Wario, Roba and Kaufmann, 2016) or the Fulani as *benndi* (Turner, 1999). This type of herd is herded from a village-based enclosure to the pasture each day. It consists mainly of lactating cows and their calves, as milk and offspring are key production goals in this livestock management system (Mwacharo and Drucker, 2005), and. Milk is both home-consumed and sold (Dossa and Vanvanhossou, 2016). Due to its economic importance, households strive to keep this herd at their home location all year (Turner, 1999). The system has come under pressure through the expansion of fields in many areas that make grazing during the rainy season increasingly difficult (Dongmo et al., 2012; Liao et al., 2017). In this context, preventing further escalation of farmer-herder conflict must be a clear policy priority in the system.

***Pastoral work oxen*** are usually kept together with dairy animals in a household herd (Moll, Staal and Ibrahim, 2007; Dongmo et al., 2012) as their low number does not enable separate management, but we want to mention them separately, as not all dairy herds contain work oxen – depending whether ploughing is practiced by the household. However, in some areas like Zambia, farmers have a different strategy, i.e. joining the ploughing animals of multiple households to form a joint herd (Lubungu, 2018). Draft animals are not typically owned by the poorest households, who likely need to exchange labour power to access them (Francis, 1988; Hochet, 2006). As mechanization is only viable in contexts with stronger cropping intensity and market access (McIntire, Bourzat and Pingali, 1992, pp.48–52), the presence of work oxen can indicate farming systems with stronger crop-livestock interactions, not only through ploughing, but also grazing on harvested fields and use of manure and animal droppings. In such environment intensification strategies can be suitable.

***Sedentary ruminant herding*** refers to herds that are herded to graze on pastures but return to the same encampment every evening, just like a dairy herd. However, these herds consist of sheep or goats, which are not usually milked and are kept mainly for reproduction (Armbruster and Peters, 1993; Kalinda, Filson and Shute, 2000).

***Rainy season transhumance*** it is practiced where herding in the rainy season is constrained by abundant crop fields and often involves moving cattle to more arid regions further North (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. While herders consider this a different kind of herd (e.g. *garci* in Fulani) it is connected to the dairy herd as stock are frequently exchanged between these herds (Turner, 1999; Shinjo, 2017). As larger herds are more likely to go on transhumance (Turner and Hiernaux, 2008) and herding increasingly depends on non-family labour (Turner, 2009), poverty-reducing interventions should target hired herders rather than herd owners.

***Dry season transhumance*** contrast with rainy season transhumance, as it is driven by a search for water and pasture resources, if local resources diminish (Adriansen, 2002 Paper D). Such transhumance mainly has advantages, where it can exploit a spatial gradient (altitude, latitude, floodplains), that outweighs the energy requirement of movement. Households with small or weak herds, or insufficient labour are less likely to go on transhumance (Turner and Schlecht, 2019). An exception can be herds of rams intended for sale during Tabaski, for which dry season transhumance, even to far pastures with hired herders can achieve substantial income (Adriansen, 2002 Paper D).

***Mobile herds*** are herds that are herded around a constantly shifting home base. This could mean the entire household moves yearly between rainy season and dry season areas, or only part of the households animals are kept in constantly shifting satellite camps (Moritz, Ritchey and Kari, 2011; Wario, Roba and Kaufmann, 2016). Such herd splitting is mainly practiced by households with large livestock wealth, e.g. herds larger than 100 heads of cattle (Bassett, 1994).

***Stall / compound fed dairy*** are kept in a stable or tethered all year. The feed consists mainly of crop residues like maize bran and some fodder crops like napier grass (Nalubwama et al., 2016). It is practiced in areas without sufficient communal grazing resources and with small farm sizes (Moll, Staal and Ibrahim, 2007; Castellanos-Navarrete et al., 2015). The system is one of the few, where AI is commonly practices and exotic breeds or cross breeds are used (Kawonga et al., 2012; Nalubwama et al., 2016). Herds are small, often 1-5 head, and dominated by cows and claves, as milk and offspring are the main production goals. Milk is both sold for income and consumed at home (Moll, Staal and Ibrahim, 2007; Nalubwama et al., 2016). Given the small farm sizes where the system is practiced, an intensification strategy is needed and suitable. As this system requires considerable investments like fodder crops, artificial insemination, and hired labour, it is practiced by relatively well-off households, while the poor are more likely to have stall / compound fed subsistence stock (Castellanos-Navarrete et al., 2015).

***Tethered subsistence stock*** are livestock kept by resource-poor household in areas, where the absence of sufficient communal farming land prevents free roaming. Livestock

are commonly tethered, and poor grazing resources are supplemented with crop residues and collected grass found off-farm (Castellanos-Navarrete et al., 2015). Maintaining herd sizes is crucial, as animals serve as a cash reserve to sell in times of distress (Castellanos-Navarrete et al., 2015) – although cows also provide milk for sale and home consumption (Nalubwama et al., 2016; unpublished data collected for Graf and Mack, 2018). However, because of differences in management and use of local breeds, milk yields are lower than in the stallfed dairy system (Nalubwama et al., 2016; unpublished data collected for Graf and Mack, 2018). Besides the resource-poor, some households owning some stall/compound fed dairy cows keep a separate group of tethered subsistence stock (unpublished data collected for Graf and Mack, 2018). Despite it's crucial function in ensuring the resilience of poor households, this management system remains understudied.

***Monogastric livestock rearing*** refers to monogastric livestock, mainly pigs, that are stallfed and engage in both breeding and rearing of offspring. The main feed source are crop residues and processing by-products like cereal brands, palm kernels or brewer's waste (Nsoso, Mannathoko and Modise, 2006; Fualefac et al., 2014; Francis et al., 2016). This makes the system widespread in urban and peri-urban areas across the continent (Youssouf et al., 2014; Ikeya, 2015). Flocks mainly consist of sows and piglets with numbers below 10 sows (Kambashi et al., 2014; Ikeya, 2015; Munzhelele et al., 2017). Breeding is done through natural mating, with piglets born throughout the year (Nsoso, Mannathoko and Modise, 2006; Munzhelele et al., 2017). Using hired labour for the flock is not uncommon (Kambashi et al., 2014; Ikeya, 2015; Francis et al., 2016). Pigs are mostly reared for income, with slaughter for home-consumption confined to special occasions like New Year, Christmas, or weddings (Kambashi et al., 2014; Youssouf et al., 2014).

***Specialized farms*** is an umbrella term for any farm that specializes in any part of the production cycle, e.g. breeding, fattening, or layer farms. Animals are generally kept in-doors and fed commercial feeds, crop residues or by-products such as cotton seed cake and fish meal (Mbuza et al., 2017). Stock numbers are comparably large, e.g. several hundred chicken. The farms are profit-oriented and use hired labour (Nmadu, Iwuajoku and Jiya, 2012; Ogbonna and Emerole, 2018).

## Table 2: Overview of key livestock systems and their characteristics

| Livestock system | species | Feed | Confined by (day) | Confined by (night) | crop-livestock interaction | stock repro-duction | labour | land | production goal | economic function | number | mobility |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Free roaming** | Chicken<br>Pigs<br>Sheep<br>Goats<br>Cattle | grazing or scavenging supplemented with kitchen scraps, crop residues, by-products or fodder crops | **Free roaming** | Stable or sharing house with people or none | [stubble grazing; manuring from night shelter] | natural mating | little labour demand; usually family labour | commons | Meat, offspring, [wool]<br>(eggs are usually left to hatch) | crisis buffer, festivities, income | 5-40 chicken<br>10-100 sheep /goats | no |
| **Seasonal free roaming** | Pigs<br>Sheep<br>Goats<br>Cattle | grazing or scavenging supplemented with kitchen scraps, crop residues, by-products or fodder crops | **Dry season free roaming**<br><br>Growing season: tethering, herding, stable | Stable, kraal or sharing house with people | Sheep & goats: crop residues for grazing or feed, animal droppings [all: manuring from night shelter] | natural mating | little labour demand; usually family labour | commons | Meat, offspring, milk, [labour] | crisis buffer, income, crop-livestock interaction | 1-20 pigs<br>10-40 cattle | no |
| **Mobile herd** | Cattle | grazing or scavenging | **herding** | Kraal | no | Natural mating | Family and often hired labour | commons | offspring [meat, milk] | income, accumulation, crisis buffer | ~80 | **constant shift of camps** |
| **Rainy season transhumance** | cattle, sheep, goats | Grazing or scavenging supplemented by crop residues [fodder crops] | **herding** | Kraal | Animal droppings, stubble grazing [manuring from night shelter] | Natural mating | Family and often hired labour | Commons or grazing fee | offspring [meat, sheep & goats: milk] | Income, accumulation, crisis buffer | large | **Rainy season** |
| **Dry season transhumance** | sheep goats | Grazing or scavenging | **herding** | Kraal | Stubble grazing (exchange) | Natural mating | Family [hired labour] | Commons or grazing fee | offspring [meat, sheep & goats: milk] | Income, accumulation, crisis buffer | 50-1500 | **Dry season** |
| **sedentary ruminant breeding** | sheep goats | Grazing, [supplemented by crop residues, kitchen scraps or fodder cropping | **herding** | Stable or kraal, [sharing house with people] | [manuring, fodder cropping, stubble grazing] | Natural mating | Family or hired | Commons or private | Meat, offspring, [wool] | Income, home consumption, [festivities] | 1-30 sheep / goats | **no** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pastoral work oxen** | Cattle | grazing or scavenging supplemented with crop residues or by-products | **Herding** | Stable, kraal or tethering | Animal traction, Stubble grazing, animal droppings or manuring from night shelter | - | Family [hired labour] | commons | **Labour, meat** | Labour | | no* |
| **Dairy herding** | Cattle | **grazing or scavenging** supplemented with crop residues or by-products | **Herding** | Stable, kraal or tethering | Stubble grazing, animal droppings or manuring from night shelter | Natural mating | Family and often hired labour | commons | **Milk,** offspring, meat | Income, home consumption, [drowry] | 1-50 | no* |
| **Stall / compound fed dairy** | Cattle | **Fodder crops and crop residues** supplemented with grazing, collected grass… | **Stable or tethering** | Stable, tethering or kraal | manuring, crop residues (feed or grazing) | Natural mating, AI | Family and often hired labour | private [small common areas] | **Milk,** offspring [meat] | home consumption, income | 1-10 | no |
| **tethered subsistence stock** | Cattle, goats | **Crop residues, collected grass,** supplemented with grazing, kitchen scraps… | **Stable or tethering** | Stable, tethering or kraal | manuring, crop residues (feed or grazing) | Natural mating | Family labour | private [small common areas] | offspring | crisis buffer | 1-4 | no |
| **monograstric breeding** | Pigs | Crop residues and by-products, at times supplemented with fodder crops, mineral supplement, kitchen scraps or gathered feeds | **Stable** | Stable | [manuring] | natural mating | Family labour [and hired labour] | private | **Meat, offspring** | income, festivities | 1-50 | no |
| **Specialized farm** | Chicken Pigs | Commercial feed, crop residues or processing by-products | Stable | Stable | [manure sales] | Buying young stock | Family and hired labour | private | **Only one** Layer farm / Poultry farm / Breeder farm / | income | >100 | no |

# 3. Empirical validation

## 3.1. Methodology

To demonstrate the use of our classification, we apply it to a secondary dataset, the IMPACTLite dataset collected by ILRI (2010). More specifically, we classify the livestock in 3 study locations, that would fall into the category of rainfed mixed farming systems in arid/semi-arid tropics and sub-tropics (MRA) according to the classification by Seré and Steinfeld (1996).

### 3.1.1. The IMPACTLite dataset

The IMPACTLite dataset provides data for 15 benchmark sites from East Africa, West Africa and South Asia. It includes detailed information about agriculture production systems and livestock related activities, land and labour use; as well as resource flows between crop, livestock and non-agricultural activities. These data are available in the form of separate rosters, e.g. livestock roster, activities roster etc. that can be joint through identifier variables. It is thus uniquely suited to assess farmers' production systems and their dynamics. ILRI collected the dataset in the context of the “Integrated Modelling Platform for Mixed Animal Crop systems (IMPACT), which ILRI developed to facilitate farming systems evaluations (ILRI, 2010).

For this paper we use data from 3 sites: Yatenga (Burkina Faso), Borana (Ethiopia), and Kaffrine (Senegal). Farms in the dataset can be classified as “rainfed mixed semi/arid” in Serè and Steinfeld (1996), as they are located in semi-arid areas (CCAFS, 2015) and do both crop and livestock production. The sites are depicted in figure 2:

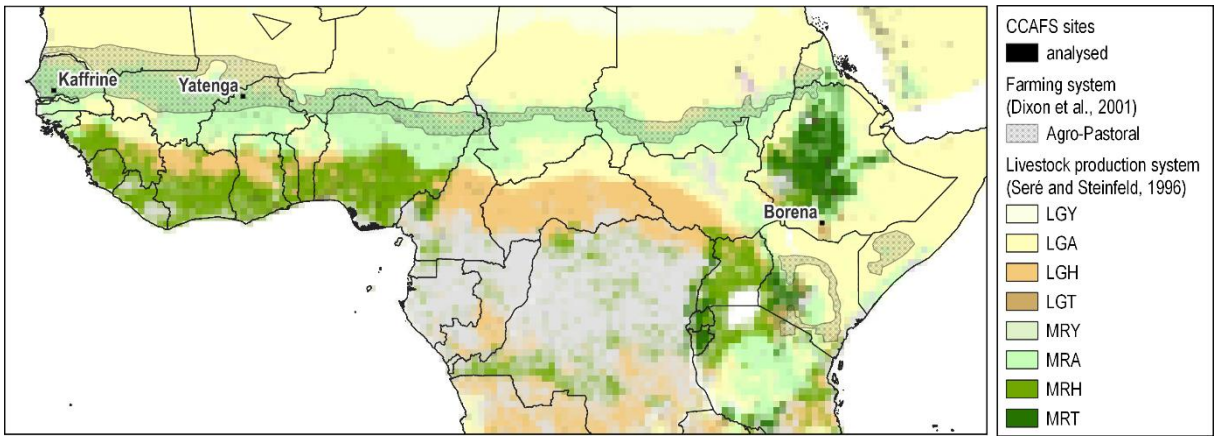



**Figure 1: Locations of selected IMPACTLite study sites**

### 3.1.2 Data analysis

The first step included classifying the livestock into our categories. While the IMPACTLite dataset does have detailed information on farming practices, it does not contain all variables that characterize a livestock management system, as outlined in table 1. It also contains

only around 150-200 households per site, limiting the number of observations per livestock management system. Table 3 shows the variables we did use to classify the herds:

### Table 2: Classification of herd types in data analysis

| Livestock management system | Classification criteria |
|---|---|
| Free roaming | No confinement activities reported in any season. (Confinement activities could include herding, tethering, transhumance, fence maintenance, or stable cleaning.) The stock is not fed daily (with fodder crops or crop residues). |
| Seasonal free roaming | Confinement activities are reported for some, but not all seasons. |
| Sedentary ruminant herding | Livestock is herded throughout the year. No transhumance.<br>(We couldn't detect difference between management of cows and other cattle.) |
| Stall / compound fed | The household reports the activity "stallfeeding" |

In a second step, we compared variables regarding livestock production between the identified systems using summary statistics and t-tests.

## 3.2. Results

We were able to classify a high proportion of animals in the dataset: 99.5% in Yatenga, 94% in Borana and 91% in Kaffrine. Free roaming is the most common livestock management system in Yatenga (62% of animals) and Kaffrine (67% of animals), while in Borana herding was most common, with 61% of animals being herded (see figure 3). Only in Kaffrine did we find some, more precisely 8, stallfed animals.

Table 4 depicts key differences between the livestock management systems in the different sites. Except for the Borana site, households that practice ruminant herding have considerably larger livestock holdings than households with other livestock management systems. In the Yatenga and Borana site, hired labour is mostly associated with ruminant herding: the most prevalent task that farmers hire labour for (except medical services) is herding. Consequently, hired labour is more likely in ruminant herding or seasonal free roaming herds, which are often herded for part of the year. In the Kaffrine site, the most common task for hired labour is feeding, which is particularly common in herds that are classified as free roaming. Nevertheless, farmers also use hied labourers for herding and watering.

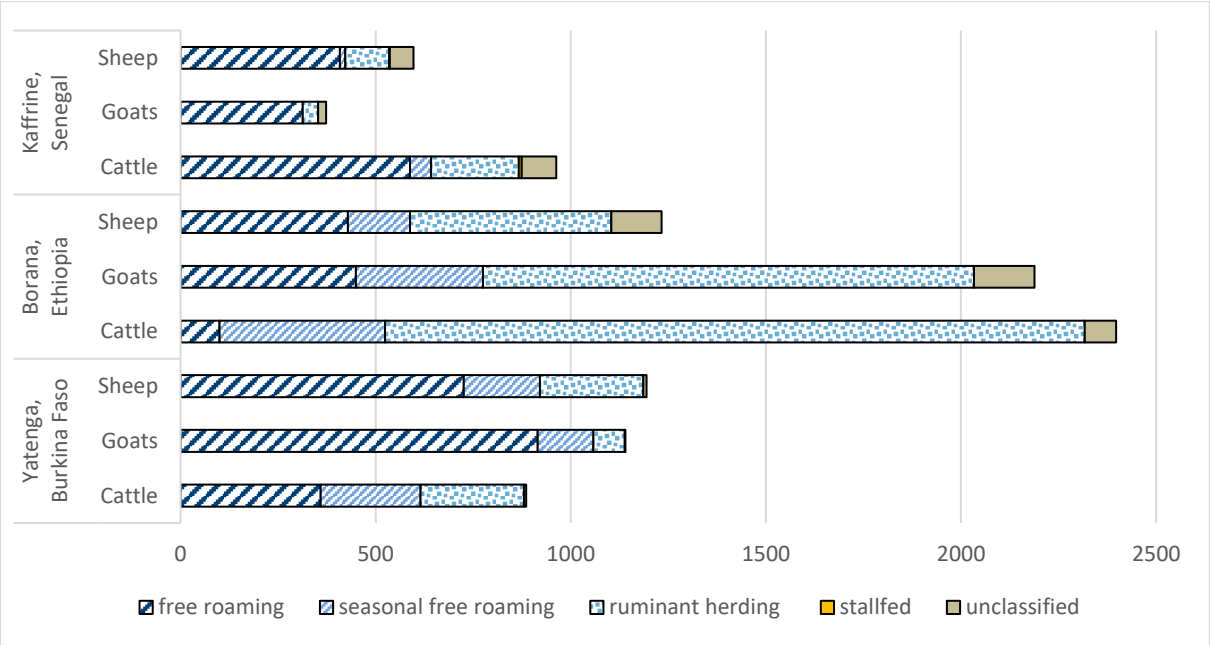



**Figure 2: Livestock management systems by herd type at the selected CCAFS sites**

Fodder crops are uncommon across sites; only in Kaffrine fodder crops are used by more than a negligible share of farmers. Crop residues are used as livestock feed in a considerable share of herds in Kaffine and Yatenga. Herds under seasonal free roaming and ruminant herding are more likely to receive fodder crops or crop residues.

**Table 3: Comparison of livestock management systems, regarding their mean herd size, use fodder crops and crop residues as livestock feed and use of hired labour**

| Location | Management | Nr | Herd size | % hired labour | % fodder crops | % crop residues |
|---|---|---|---|---|---|---|
| Kaffrine | free roaming | 115 | 12.0 [a] | 20.9% | 2.5% | 31.3% |
| | seasonal free roaming | 11 | 23.1 [a] | 63.6% | 18.2% | 91.7% |
| | ruminant herding | 19 | 23.3 [a] | 36.8% | 9.5% | 65.2% |
| Yatenga | free roaming | 156 | 16.1 [a] | 0.6% | 0.6% | 46.4% |
| | seasonal free roaming | 32 | 23.2 [ab] | 46.9% | 0.0% | 75.7% |
| | ruminant herding | 34 | 25.6 [b] | 58.8% | 0.0% | 66.7% |
| Borana | free roaming | 91 | 31.1 [a] | 0.0% | 1.1% | 0.0% |
| | seasonal free roaming | 53 | 32.3 [a] | 30.2% | 5.0% | 0.0% |
| | ruminant herding | 159 | 30.0 [a] | 7.5% | 0.0% | 1.9% |

[a] *values with the same letter are not significantly different.*

*Herd size and hired labour have the household as observation, fodder crops and crop residues use differently managed livestock groups as the unit of observation*

## 4. Future application

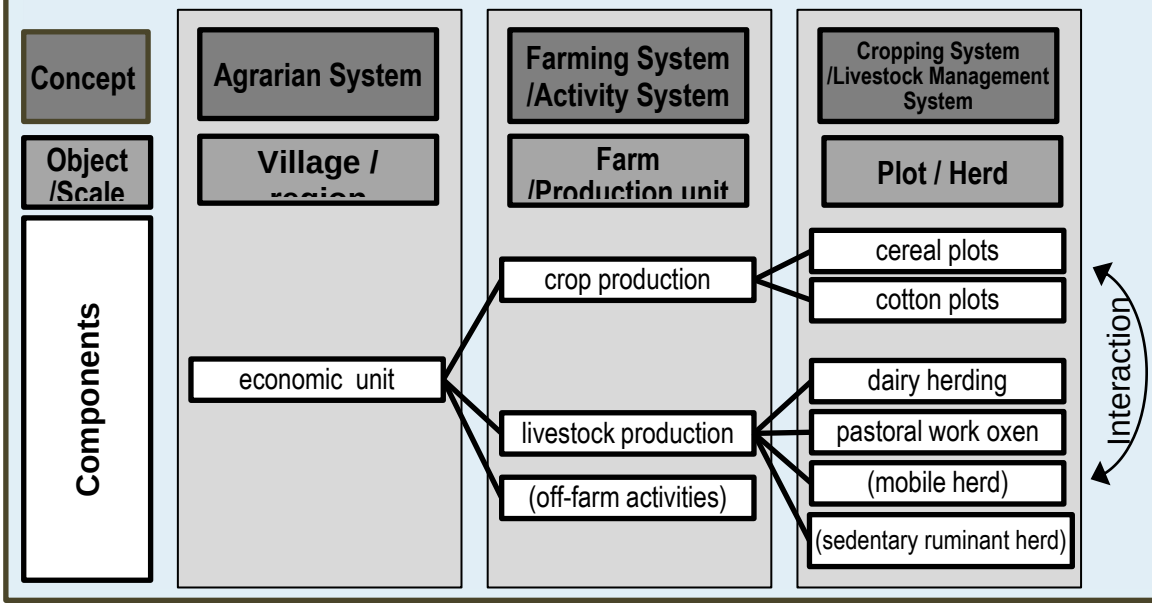
The concept of livestock management systems can enrich both research of farming systems and interventions into these systems.

### Enrich our understanding of livestock farming systems

The livestock management systems outlined in table 2 form building blocks of households' farm systems, which may combine multiple livestock management systems with cropping or off-farm income. In box 1 we give an example of how a combination of different livestock management systems and crop production systems forms livestock farming system. Describing livestock management systems of a household separately, results in much clearer descriptions and analysis of household farm systems.

### Box 1: Herds in agropastoral farming systems

Agropastoral farming systems often combine dairy herding, pastoral work oxen and potentially a sedentary ruminant herd and a mobile or transhumant herd. The animals are split into multiple herds: a household herd (*suredji* in Fulani) involves lactating cows, calves and work oxen. These livestock are herded in the territory close to the settlement and return each night to be corralled. They graze on natural vegetation and the main production goals are milk and animal traction. This is a a dairy herding system with pastoral work oxen. The bush herd (*horedji* in Fulani) includes heifers, non-suckling cows, young bulls and bulls. It is herded further away from the settlement and may temporarily stay in satellite camps or go on transhumance. This herd is primarily kept for reproduction and animals (cows and calves) are moved between both herds depending on lactation status. This can be a sedentary ruminant herding system or dry season transhumance. A key reason for herding is to avoid damage to crop fields. Crop livestock interactions include grazing on crop residues, using weeds as feed, fertilization through animal droppings and manure application as well as animal traction (see e.g. Dongmo et al., 2012)



The variables in table 1 can be included into household survey questionnaires relatively easy, as they are straightforward to answer and thus do not take much interview time. However, using these criteria in questionnaires or sampling is currently not common practice, and it was not easy to find secondary data detailed enough to develop and test the classification. We recommend making these standard variables in future livestock surveys.

Figure 4 highlights the variety of livestock management practices that fall into a single LPS as defined by Sére and Steinfeld (1996), in this case rainfed mixed production systems in semi-arid areas. While ruminant herding dominates in Borana, Yatenga is characterized by a large share of free roaming and seasonally free roaming livestock. In Kaffrine, the use of fodder crops is more prevalent than in the other sites. Our classification thus contributes to a more fine-grained, yet easily comparable understanding of livestock management practices. A key finding is also the high proportion of free roaming and seasonally free roaming livestock, a livestock management system that generally receives little attention in livestock related research.

## Assess changes in livestock production systems

Its detailed focus on management practices, as well as its relatively low data requirements make the classification suitable to study changes in livestock production. The Borana site in the analysis is an illustrative example. It has experienced considerable change in livestock management practices over the last decades: Formerly Borana pastoralists based their livelihoods almost exclusively on cattle, combining mobile herds of male cattle and dry cows in *foora* lands (pastures distant from the settlement), and dairy herds with lactating cows and calves in *warraa* lands close to the settlements. Following considerable livestock losses during droughts and government efforts to settle Borana pastoralists, most households have taken up crop production now and diversified their livestock holdings to include goat, sheep or camels (Degen, 2011). Thus, the site no longer features the farming systems and LPS depicted in figure 2. In the classification by Sére and Steinfeld this constitutes a shift from a grassland based (LG) to rainfed mixed system (MR). Dixon et al. (Dixon et al., 2019, pp.43–47) reclassified the area from a pastoral to an agro-pastoral farming system. In our analysis, we further picked up the new existence of free roaming (17%) or seasonal free roaming (16%) livestock. This is a considerable development, that has also been reported elsewhere (Adriansen, 2006) and deserves research attention. Kariuki et al. (2024) have recently used the proposed classification of livestock management practices to describe livestock development pathways in Africa.

## Shared understanding with livestock farmers

In areas where it is common to have multiple herds, livestock keepers themselves distinguish different types of livestock management systems. This is evident in the fact that specific words for these herd types exist in the languages of multiple pastoral peoples, like Fulani and Borana (see e.g. box 1). The classification has incorporated their herd categories. However, even where such categories are not ingrained into local languages, livestock farmers find it intuitive to describe their herds separately.

## Guide more targeted survey samples and development interventions

When researchers want to assess the effect of one management intervention ceteris paribus, sampling only herds that are managed similarly will reduce the variance of fixed, explanatory and confounding variables and allows for better results with small sample sizes. Alternatively, a stratified sample including multiple herd types could strengthen the projects generalizability.

Interventions should consider the prevalence of livestock management systems, as well as the economic endowments of livestock keepers. The different livestock management systems also serve different economic functions for the livestock keeper's household (see table 3) and can be linked to the economic endowment of livestock keepers. Whereas free roaming chicken may be kept by all social strata, herds that go on rainy season transhumance require access to substantive livestock capital and labour; i.e. they are unlikely to be owned by the very poor. In the Yatenga site, households that have free roaming livestock, have significantly smaller livestock holdings and only 0,6% of them uses hired labour (see table 4) – both indicators that these are less affluent households. To enhance the resilience of poor households, interventions should target the free roaming, seasonal free roaming systems. The high number of livestock managed according to these livestock management systems is another important finding of the analysis and another reason to target these systems.

## Inform better the data structures

When researchers are aware that households may own multiple livestock management systems of one species, they can adjust their data collection tools to accommodate this diversity. A standard data collection tool for livestock research is a livestock roster, giving a basic overview of the species and often gender and ages of the households' livestock. This data format implicitly assumes, that all animals of a certain species are managed together. However, when households manage more than one herd of the same species (or herds with multiple species) this approach can lead to confusing information. Table 3a and 3b

depict some data on livestock husbandry collected from a household in Western Kenya in 2017, which manages a stallfed dairy cow and a dairy herd. Adding the possibility to distinct between herds, has clearly enhanced the quality and clarity of the data.

### Table 4a: household data by livestock category (unpublished data collected for Graf and Mack, 2018)

| information from livestock roster | | | | information from other questions | |
|---|---|---|---|---|---|
| category | nr | breeds | responsible person | daytime confinement (wet and dry season) | feed (wet & dry season) |
| dry cow | 2 | Zebu | son | herding | grazing |
| lactating cow | 1 | Ayrshire | wife, hired workers | stable | napier grass |
| calves | 4 | Ayrshire, Zebu | wife, hired worker, son | stable, herding | grazing, napier grass |
| males | 4 | Ayrshire, Zebu | wife, hired worker, son | stable, herding | grazing, napier grass |

### Table 5b: household data by herd (unpublished data collected for Graf and Mack, 2018)

| Herd nr | information from livestock roster | | | | information from other questions | |
|---|---|---|---|---|---|---|
| | category | nr | breeds | responsible person | daytime confinement (wet and dry season) | feed (wet & dry season) |
| 1 | lactating cow | 1 | Ayrshire | wife, hired worker | stable | napier grass |
| 1 | calves | 1 | Ayrshire | wife, hired worker | stable | napier grass |
| 1 | males | 3 | Ayrshire | wife, hired worker | stable | napier grass |
| 2 | dry cow | 2 | Zebu | son | herding | grazing |
| 2 | calves | 3 | Zebu | son | herding | grazing |
| 2 | males | 3 | Zebu | son | herding | grazing |

When analysing the data, this data structure enables comparisons between systems, as well as improving estimation with data from across systems. Using the example of Table 4a and 4b, it is obvious that cows from the 2 herds would have considerably different milk outputs. When describing dairy productivity in the area, disaggregating figures by herd types can add clarity, as herd type likely explains a large share of the variance in that variable. By including herd type in regression analysis, the enhanced data structure can also improve estimation results.

## 5. Conclusion

We have proposed and described a novel approach to classify livestock management systems. The advantage of the proposed livestock management system classification is that it is both simple and specific at the same time. On herd level, 12 categories suffice to describe the most prominent management systems in Sub-Saharan Africa – even though on farm level numerous combinations are possible. In the dataset we used for empirical application the proposed categories describe the management of >90% of animals in all sites. Also, there are clear differences in these categories regarding management factors like livestock holdings, feeding practices and hired labour.

Livestock research can benefit from the described livestock management systems approach in multiple ways: Firstly, it provides a simple but specific framework for describing and analysing the different livestock components in a farming system. Secondly, its more fine-grained focus on livestock management on herd level is more suitable for detecting shifts in local livestock management practices than existing classifications. Thirdly, it builds on shared conceptual understandings with livestock keepers and builds on variables that are comparably straight-forward to collect. And lastly, such descriptions of average herds can inform strategies for intervention and technology development in such endeavours as animal health, feeding and genetic improvement. Given their easy identification – based on only few characteristics the new classification is well suited to inform rapid assessments of livestock management in an area.

## 6. Annex

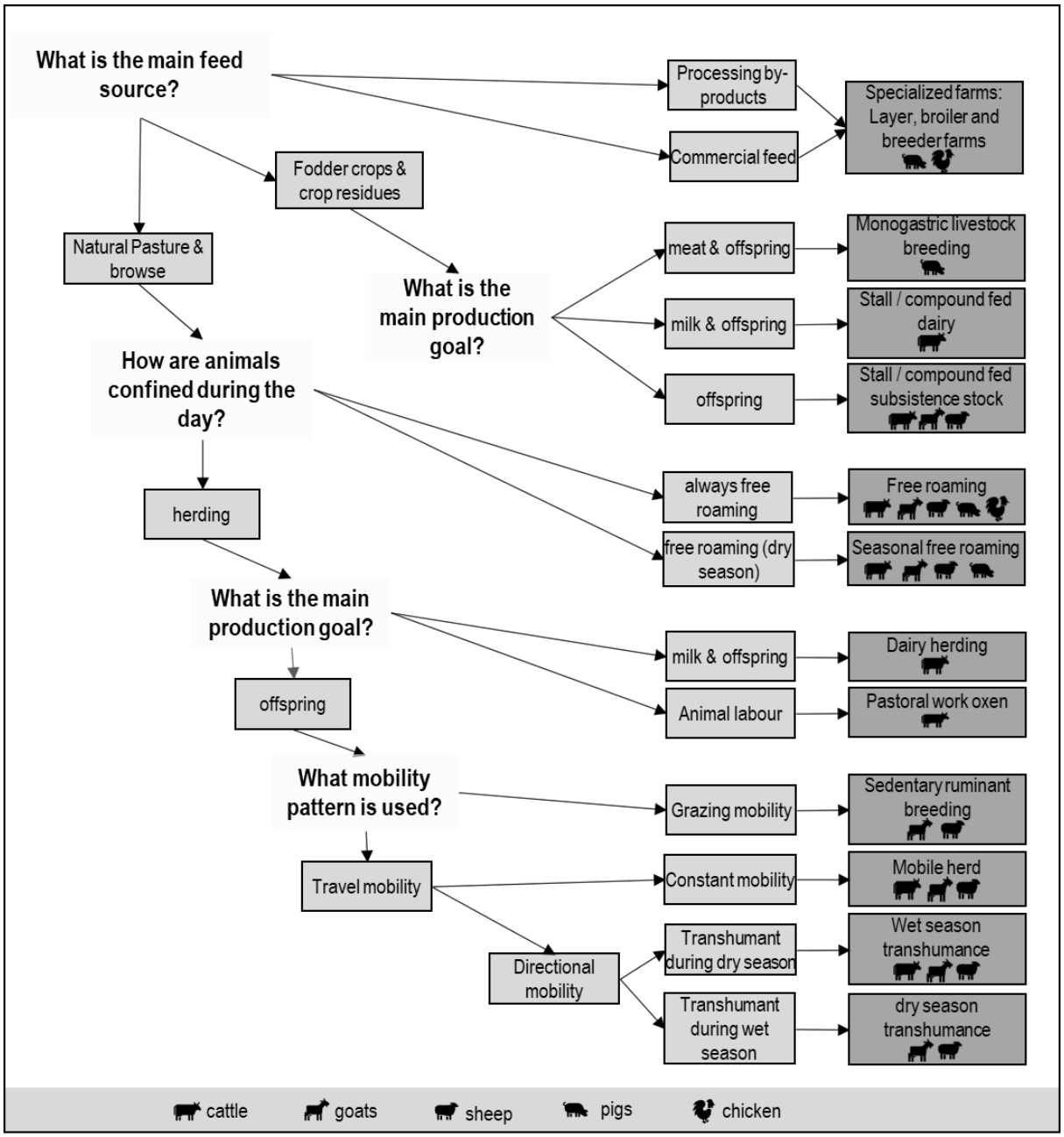



**Figure 3: Quick guide to classifying a livestock management system**

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