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RESEARCH ARTICLE

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Socio-productive characterization and agroecological analysis of Spanish transhumance

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ABSTRACT

Transhumant livestock systems play a key role in the socioecological sustainability and dynamics of rural territories, contributing to local, healthy, and culturally appropriate food supplies, as well as to ecosystem and social functions and processes. In Spain, transhumance represents an ancestral livelihood with significant cultural and identity value that has endured substantial land-use and socioeconomic changes. This article presents a socio-productive characterization of transhumant livestock systems in Spain from an agroecological perspective, encompassing their economic, productive, socio-cultural, political, and governance aspects. We followed an analytical mixed-methods approach and conducted 84 interviews with transhumant herders from eight regions of Spain. The methodology included content analysis and quantitative multivariate analyses and evaluated the alignment of transhumant practices with agroecological principles defined by the United Nations High-Level Panel of Experts on Food Security and Nutrition (HLPE). The findings reveal diversity among Spanish transhumants and a common cultural and practical foundation, shaped by similar political, economic, and ecological pressures and circumstances. We identified three types of transhumant livestock systems, corresponding to transhumant groups from the *Conquense* and *Segoviana* drove roads and from *Santiago-Pontones*. Despite constraints from agrarian intensification policies, market dynamics, environmental changes, and regulatory issues, transhumant herders demonstrate resilience, drawing strength from their social bonds, common land-tenure schemes, heritage, intra-family support, and efficient resource-use practices. There is a need for greater research, policy adaptation, and social recognition of transhumant systems to ensure food security, sustain rural livelihoods, and the coexistence of food systems and nature.

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Introduction

Pastoralism is an ancient activity that takes place in over 100 countries across all inhabited continents (Manzano et al. 2021), on which between 200 million and 1 billion people depend for their livelihoods (Lucatello et al. 2020), and from which local communities and global markets are provided with healthy, culturally appropriate, and sustainable sources of food, fiber, and materials (Fernández-Giménez, Ravera, and Oteros-Rozas 2022). Beyond its economic value, pastoralists also make essential environmental, social, and cultural contributions (Manzano-Baena and Salguero-Herrera

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2018) that are crucial for biodiversity conservation (Aguilera-Alcalá et al. 2022; Durá-Alemañ et al. 2024) and for climate-change mitigation and adaptation (Liechti and Biber 2016).

Transhumant livestock systems (TLSs) are pastoral migration-based practices managed by herders who seasonally move their livestock to higher or lower altitudes and/or latitudes in search of areas with high primary productivity and favorable climate conditions (Oteros-Rozas 2013). Shorter movements, particularly in altitude, are also known as transterminance (Serrano-Zulueta et al. 2024), and our use of the notion of transhumance includes these migrations. Transhumant herders typically use two or three grazing areas per year (Oteros-Rozas et al. 2014) and rely on rangeland, which is the most widespread land type on Earth (25–45% of the land surface) and includes habitats shared with wild species such as native grasslands, shrublands, savannas, and marshes (Reid, Fernández-Giménez, and Galvin 2014).

TLSs are often found in mountainous areas, where herds are moved between highland and lowland areas according to seasonal changes (Liechti and Biber 2016). In Spain, summering highlands or mountain grasslands are commonly managed as communal pastures (*montes* or *pastos comunales*), which are publicly owned grasslands collectively managed by a group of herders with or without the involvement of public administrations. By contrast, wintering lowlands are often privately owned and rented by the herders (Baur and Binder 2013; Eychenne and Lazaro 2014).

TLSs are crucial for ecosystem functioning and service provisioning in various social-ecological settings (Bowden and Herring 2021; Fernández-Giménez 2019; Oteros-Rozas et al. 2013), especially in semi-arid and semi-humid areas, and also contribute to the sustainability and resilience of cultural landscapes (Oteros-Rozas et al. 2014). For instance, beyond food and fiber provisioning, transhumant herds contribute to seed dispersal and soil fertilization (Manzano and Malo 2006; Timpong-Jones et al. 2023). They also participate in trophic chains of predators, scavengers, insects, and plants (Aguilera-Alcalá et al. 2022; Carmona et al. 2013; Manzano-Baena and Salguero-Herrera 2018) and contribute to public goods and services such as wildfire prevention and resilience, biodiversity protection, carbon sequestration, the creation and preservation of traditional ecological knowledge, and the promotion of cultural diversity and identity (Dean et al. 2021; Oteros-Rozas 2013; Oteros-Rozas et al. 2013; Rincón-Madroñero et al. 2024).

European transhumance is also associated with specialized practices and activities, including the provisioning of origin-certified milk and meat products, the maintenance of protected areas and heritage infrastructure (e.g., shelters, drove roads, stonewalls, and reserves), the preservation of autochthonous livestock breeds, the facilitation of seasonal festivities, and the perpetuation of local governance institutions related to pastures and product distribution (Liechti and Biber 2016). In recent decades, extensive livestock farming and transhumance—and, consequently, grassland ecosystems in European countries—have undergone both abandonment and intensification, resulting in desertion from mountain regions that cannot match the profitability of intensified lowland systems (Liechti and Biber 2016). The withdrawal of subsidies under the European Union (EU) Common Agricultural Policy (CAP) for marginal grazing lands, together with the promotion of intensive livestock systems, has played a key role in this process (Fernández-Guisuraga et al. 2022). Traditional ecological knowledge is essential for transhumant systems to survive and adapt to these changes (Oteros-Rozas et al. 2013).

As part of the agroecology and sustainable farming debate, we can learn a great deal from TLSs. Furthermore, TLSs successfully address several goals of the EU, including strategies to promote "farm-to-fork" (F2F) provisioning systems, Biodiversity 2030, and the CAP in relation to environmental and sustainable agricultural transitions (European Commission 2021; Liechti and Biber 2016). Despite scientific and public acknowledgment of this relevance, comprehensive, systematic, and current information on European TLSs is scarce.

In 2009, transhumant activities occurred over four million hectares of agricultural land (European Commission 2009). In Spain, pastoral systems cover approximately 30 million hectares, which is 60% of the country's surface, including *dehesas*[1] (Campos et al. 2010), grasslands, ligneous crops, stubble, fallow fields, and forest lands (Zabalza et al. 2021). Transhumance is an ancestral livelihood that involves migrations both on foot (through a protected and widely extended network of ancient drove roads [*Cañadas Reales*] that are still in use) and with trucks. Transhumance practice and extensive

livestock systems have endured despite enormous changes in land-use and socioeconomic circumstances (Manzano-Baena and Salguero-Herrera 2018). However, they have notably declined in recent decades and centuries, due to the intensification trend of livestock systems. In the mid-eighteenth century, the Council of *La Mesta* (Marín Barriguete 2015) recorded 3,750,000 transhumant animals; however, by the 1990s, the census counted only 1,496,229 animals.[2] The most recent data from 2011 reports 1,290 owners of transhumant sheep and goat herds and 7,103 transhumant cattle herders (MAGRAMA 2013). However, these numbers are derived from records of a traceability system, so they should be considered estimates, as there is no updated census for transhumant herds.

According to an official report on transhumance in Spain, the dismantling of livestock-drove roads has played a significant role in this decline (MAGRAMA 2013). Since the 1960s, most transhumance movements have been made by truck, and some involved trains until the end of the 1990s. Today, foot trips are made mainly for short distances, and long-distance foot transhumance is rare but still exists in at least three *Cañadas Reales*. Only 10% of transhumant movements between different regions of Spain and 40% of internal movements are made on foot (MAGRAMA 2013).

Threats to pastoralism in Spain and elsewhere in Europe include rural depopulation, a shortage of skilled herding labor, high input costs, low profitability of livestock products, climate variability, conflicts with wildlife, tensions with public administrations, and insufficient specific subsidies (Morales-Reyes et al. 2025; Scoones 2021). Factors related to gender and generational issues have also contributed to transhumant abandonment. The number of women participating in transhumant systems is nearly equal to that of men, considering salaried and non-salaried labor. As operators, their numbers have also increased, making up more than one-third of those under 25 years old. However, men remain the primary decision-makers on livestock farms (Fernández-Giménez, Oteros-Rozas, and Ravera 2021).

To our knowledge, no comprehensive, transversal, systemic, and multi-regional characterization of Spanish TLSs has ever been undertaken, nor has there been a thorough analysis of their relationship with agroecology. This study, therefore, aims to achieve two main objectives. First, we present the current state of TLSs in Spain through a socio-productive characterization, and second, we analyze their alignment with agroecological principles. To this end, we examined both internal and external dimensions of TLSs, encompassing economic, productive, socio-cultural, political, and governance aspects, as well as dynamics, interactions, and relations among them. For the second objective, we drew upon the 13 agroecological principles (AE-Ps) defined by the High-Level Panel of Experts on Food Security and Nutrition (HLPE) of the Committee on World Food Security (HLPE 2019). Through this approach, we aim to provide insights for policies designed to prevent the decline of TLSs in Spain and across Europe, and to foster an agroecological transition within the sector.

The following section outlines our methodology for data collection and analysis. The findings are then presented, starting with the socio-productive characterization of transhumance in Spain, addressing several topics. This section is followed by an attempt to profile and typify groups of transhumant herders and, finally, to examine the relationship between TLSs and the AE-Ps framework. Finally, we discuss our results, with particular emphasis on the current situation of TLSs and how they could be transformed to enhance their agroecological performance before offering our conclusions.

Materials and methods

Data collection

The study included 84 semi-structured interviews with transhumant herders, conducted between December 2020 and August 2021. Interviewees were based in nine of the 17 Spanish Autonomous Communities (Regions) and across 18 provinces (see Figure 1 and Table 1 for a map and table detailing their territorial distribution). Due to the COVID-19 pandemic and budget restrictions, we conducted 44 interviews by telephone and the remaining 40 in person. All the interviews were fully recorded and manually transcribed.[3]

Study participants were identified through snowball sampling (Chatterjee et al. 2021), beginning with the authors' previous connections with transhumant herders. This approach enabled access to a variety of herders operating along the most frequently used transhumant drove roads. The goal was

Figure 1. Map of the summer and winter lands used by the interviewed herders.

Table 1. Number of herders on summer and winter lands by province.

	Albacete	Alicante	Asturias	Ávila	Badajoz	Burgos	Cáceres	Ciudad Real	Córdoba	Cuenca	Huesca	Jaén	León	Lleida	Lugo	Soria	Toledo	Teruel
#Herders' summer land	1	0	7	15	0	1	3	0	0	3	0	28	11	1	0	3	0	7
#Herders' winter land	0	1	5	0	5	0	15	5	3	0	1	35	7	0	1	1	4	0

to interview as many Spanish transhumant herders as possible. Participants provided oral informed voluntary consent, with assurances regarding the confidentiality and anonymity of the interviews and their contents.

Interviews covered various topics relevant to TLSs, including:

1. Economic and productive characteristics: examining aspects related to livestock production, transhumance practice, economics, and marketing.
2. Sociocultural characteristics: exploring personal relationships with livestock-raising, labor conditions, family life, women's participation, social recognition, and perception of ecosystem services provision.
3. Political and governance characteristics: analyzing communal land governance and political participation.

For each of these characteristics, we investigated the main trends, challenges, adaptation strategies, and the herders' perspectives. See Appendix A for the interview protocol and script.

Data analysis

Qualitative analysis: content analysis

The 84 interviews resulted in 94 h of recordings, with a mean interview duration of 67 min. Of these, 78 interviews were conducted (in Spanish) with men, four with women, and two with couples (i.e.,

a man and a woman in each case). The mean age of the interviewees was 49 years (range 26–73). We coded the interview transcripts using Atlas.ti software (version 9.0.19.0), adding labels (also called "codes") to each paragraph or phrase. This process employed a pre-made list of codes based on the interview questions, which was extended with emergent coding during the analysis. We obtained a total of 55 codes and classified them into nine groups. Twenty codes from five groups were selected for study, as they included information related to the topics of the present article. The selected groups of codes were: 1) personal relationship with livestock-keeping; 2) economic and productive characterization; 3) transhumance movement characterization; 4) communal pastures; and 5) socioecological challenges. For further information on the coding, see Appendix B, which lists all the content analysis codes used and their respective groups.

After the coding process, we categorized the quotes, generating reports that grouped all the quotes linked to each code. From each report, the main trends, ideas, and statements were manually compiled into a new document that summarized all the statements in the quotes associated with each code, organizing them into general statements or topics and the specific statements or ideas related to each of them. The summaries provided in these documents enabled the identification and presentation, in the Results section, of the main discourses expressed by the herders on each subject.

Quantitative analysis: descriptive statistics and multivariate analysis

To deepen the characterization, we collected quantitative data on 43 discrete, dummy, and categorical variables and systematized this information in a Microsoft Excel database (see complete list of variables in Appendix C), from which we calculated descriptive statistics.

Given the high heterogeneity of TLSs in Spain, we conducted multivariate analyses to examine their similarities and differences. This allowed us to both identify groups of transhumants with similar characteristics among the interviewees and determine which variables most strongly influenced differences among herders. We performed arithmetic conversions and normality tests on the quantitative data selected for the multivariate analyses, which indicated that all variables followed non-normal distributions. As a result, non-parametric tests were conducted, including principal component analysis (PCA) and hierarchical cluster analysis (HCA), followed by chi-squared (χ^2) and Kruskal–Wallis (K–W) tests.

We selected variables based on their relevance for the analysis, avoiding redundancy, and including only those with significant predictive power for grouping or describing the observations. Variables with low variability and low predictive power for the observations were excluded. To maintain analytical accuracy, only variables answered by at least 70% of the herders (i.e., 60 out of 84) were included. We obtained an average response rate of 91% (the percentage of questions answered by each interviewee). Only 5 out of 84 interviewees had a low response rate (less than 82%), but all exceeded 53%. The remaining missing data were estimated using the nearest-neighbor index method.

The PCA included 11 variables: herd size by species (sheep, goats, and cattle), diversity of animal breeds, number of marketing channels, number of quality certifications, means of transport for transhumance, location changes during transhumance, distance traveled, and herders' age. We conducted the PCA, HCA, χ^2, and K-W analyses using the XLSTAeT-Student (version 2023.2.1413.1413) statistical package for Excel. Dissimilarity in the HCA was measured by Euclidean distance. Ward's method was used as the agglomeration method, and the test was truncated to 3–4 clusters. The K-W test used a significance level of 5%, asymptotic p-value, and a continuity correction.

Agroecological framework analysis

To assess if and how TLSs are relevant to agroecological transitions, we compared the socio-productive characteristics of TLSs and discussed them in relation to the 13 AE-Ps developed by the HLPE (2019). An evaluation was conducted of each AE-P relative to the transhumant herders' current practices, as identified through the socio-productive analysis. A detailed list and description of the 13 AE-Ps can be found in Appendix D.

Results

Socio-productive characterization of transhumance in Spain

We employed content analysis and descriptive statistics to conduct a socio-productive characterization of TLSs in Spain, in terms of their economic, productive, sociocultural, political, and governance characteristics.

Economic and productive characteristics

Livestock productive aspects

The average herd size was 188.9 livestock units (LSU); however, with a large standard deviation (±142.2). The breakdown by species is presented in Table 2, where herd-size numbers are estimates made by the herders at the time of the interview. Among the participating herders, 61% reported an increase in herd size over the past decade, 32% remained stable, and 7% indicated a reduction. Most have single-species herds (64%), predominantly consisting of cows ($n = 28$) or sheep ($n = 26$). Sheep and goats are the most common combination in multi-species herds ($n = 15$).

Transhumant herders play a crucial role in preserving autochthonous breeds, of which 30 were mentioned by interviewees. The majority of herders (85%) have at least one autochthonous breed, and 55% have two or more. However, only a few endangered autochthonous breeds receive public subsidies for their maintenance. Cross-breeding with exotic breeds is a common practice to improve yields and to meet buyers' requirements. This is typically made up to the first generation (F1), and the practice preserves the autochthonous breed. The rusticity of autochthonous breeds plays an important role in disease resistance, efficient utilization of grasslands, and adaptability to environmental conditions.

In transhumant systems, birth seasons are linked to pasture availability, weather, dates and areas with fewer predator attacks, dates with lower parasitosis incidence, and transhumance dates, with most occurring in winter or spring (mainly in January and March). In autumn, some sheep and goat producers also have high birth rates due to the availability of acorns, other fruits, and pruning remains, which serve as dietary supplements. Lambs are usually weaned at three months old and are typically sold to intermediaries. Male animals are replaced every two or three years through breeding, exchange, or purchase. Female replacements are mainly made through own-breeding programs and account for 10–25% of the herd annually.

Intensification was a major trend reported by interviewees, characterized by increased herd size and, in some cases, greater use of external inputs. Complementary feeding is a common practice among transhumant herders, particularly during winter, late-term pregnancy, and the early stages of lactation and breeding. Due to the high cost of fodder, herders aim to obtain feed predominantly from their own or more affordable sources, such as pasture, other grassland resources, and occasional access to stubble. However, in years with scarce rainfall, all animals are provided with some fodder.

Interviewees commonly reported rotational grazing and practices of rotative and mobile night enclosures known as *redileo* or *majadeo*, and some claimed to follow holistic management guidelines. Some herders fatten animals on their own farms to achieve greater profitability. Pasture and water quality are generally regarded as excellent. However, there are issues in certain areas related to water contamination and a decline in grass quality in the lowlands due to a drastic reduction in animal populations.

Table 2. Average, maximum, average LSU, and number of autochthonous breeds by species.

	Average	Maximum	Average LSU	Number of autochthonous breeds
Total animals	713.5 (SD: 549.8)	2,645	188.9 (SD: 142.2)	30
Sheep	862.6 (SD: 503.0)	2,600	129.4 (SD: 75.4)	5
Goats	88.5 (SD: 246.9)	1,500	13.3 (SD: 37.0)	14
Cattle	188.1 (SD: 174.5)	740	188.1 (SD: 174.5)	11

Note: LSUs were calculated according to the Eurostat (2023) definition.

Livestock sheds are used in winter for protection, sanitary procedures, farrowing pens, and to prevent parasitism. In some cases, sheds are shared with other herders. In summer, animals are usually kept in permanent or mobile pens at night, but some communal summering lands have public property sheds. Traditional wooden watering troughs called *tornajos* can be found in summer pastures, but they are being lost due to a lack of maintenance and replacement. Water sources in grasslands include natural streams, rivers, ponds, fountains, boreholes, troughs, and pipes. Very few herders report water-scarcity problems, but some need to carry water to fill cisterns during the dry season. Some herders' associations manage water-associated infrastructure.

Transhumance journeys

The interviewees reported that transhumance was often a family tradition, with older herders passing it down to younger generations. It also provides personal benefits, such as the opportunity to meet new people and to explore new territories.

> And then the entire family moved from [summering area] to [wintering area]…that makes you interact with more people, with different points of view, and it's truly enriching. (22:2)

The primary reasons herders continue, return to, or initiate transhumance are to find better weather conditions for their animals, provide them with fresh pasture, reduce feeding costs, and minimize labor associated with feeding. The state of pastures and the practice of transhumance itself depend on the rainfall regime. Better weather conditions improve animal welfare, offspring rates, herd health, and reduce the incidence of infectious diseases.

Interviewees mentioned that during summer, moving north, to higher lands, or in some cases to the coast, were ways to avoid extreme heat and access fresher grasslands; during winter, moving south, to lower or to inner lands, offered pastures and fruits for animals while avoiding extreme cold, snow, and mountain predators. Transhumance also enables herders to use natural resources more efficiently and allows them to graze their animals freely without confining them during winter. They also described how having summering and wintering lands was a strategy to increase the declared hectares, thereby increasing CAP subsidies and making transhumance more appealing. Additionally, interviewees mentioned specific subsidies available to transhumant herders in certain regions.

Transhumance stays in summer and winter pasturelands usually lasts around six months. Departure from wintering areas typically occurs at the end of May, enabling herders to reach the summering areas by around June 8, on average. Migration from summering areas begins, on average, on November 17, and they arrive at the wintering land around November 26. These dates may vary according to weather and pasture conditions, as well as the availability of water and autumn fruits, and are therefore directly affected by climate change. Other factors affecting transhumance dates include farrowing periods, sale dates, shelter availability, animal procedures such as shearing, coordination with other herders, communal pasture openings or grassland rental dates, and crop stubble availability. Sanitary and bureaucratic restrictions can also delay or impede transhumance, resulting in enormous costs and problems for herders and stress for their animals.

Most interviewees (70%) perform transhumance on foot, 25% use trucks, and 5% travel either on foot or by truck. The choice of transport mode is influenced by the availability of labor assistance, drove-road conditions, and a herder's own health. The number of people assisting with transhumance is more closely related to the transported LSU than to the number of animals, averaging 2.5 people per 100 LSU. Some basic transhumance descriptors are presented in Table 3.

Table 3. Foot and truck transhumance descriptors.

	Number of Herders	Average duration	Maximum duration	Minimum duration	Average length	Average speed	Average number of people assisting transhumance per herd
Transhumance on foot	59	9.6 days (SD: 7.5)	30 days	1 days	177.7 km (SD: 121.7)	18.6 km/day	4.3 (SD: 3.0)
Transhumance by truck	21	7.8 h (SD: 4.4)	12 h	2 h	333.6 km (SD: 204.6)	42.8 km/hour	3.1 (SD: 1.7)

Half of the interviewees reported having their wintering area in the same province as their summering area, 4% in the same region but in a different province, and 46% in a different region. The number of herders' wintering and summering areas by province, as well as their location on a map of Spain, are presented in Appendix A.

The labor shortage has increased the importance of truck-assisted transhumance, allowing herders to move their herds with minimal personnel and reach their destinations within the same day. Interviewees also stated that poor conditions and abandonment of drove roads influenced some herders to transport their animals by truck. However, for larger herds, this is not a convenient alternative, as multiple trips increase time and costs. In the past, some herders used trains as an efficient and cost-effective mode of transhumance, but this service has not been available since the early 1990s.

Interviewees reported that foot transhumance often involves horses, pick-up trucks, and occasionally donkeys to transport people, food, and equipment. It is hard and risky work, especially when crossing highways and on steep terrain. Herds have priority on roads, but police assistance to control traffic is not always available. Livestock guard dogs and shepherd dogs, called *careas*, are crucial for managing the herd and preventing livestock from entering roads and crop lands, especially when herd sizes are larger and qualified labor is scarce.

Herders observe transgenerational learning among animals related to their abilities to perform transhumance, including learning the routes and paces, with established paths proving difficult to alter. Breeds and lineages were also related to transhumance abilities.

Interviewees expressed a preference for foot transhumance due to animal-welfare considerations: animals travel calmly, eat, rest, face lower injury risks than on trucks, and have time to acclimate to new weather conditions. Herders offered different opinions concerning associated costs, but most reported that traveling by foot is cheaper than by truck, especially with family support and large herds. Although there are fewer foot transhumants than in previous times, they argue for the use of traditional drove roads to preserve heritage and ecosystem services. Herders also mentioned that foot transhumance is an activity that they enjoy and share with their family and friends. Many people come to witness the transhumance trip, and celebrations are held around it. Families involved in transhumance must continuously adapt, which can involve moving the whole family, having the herder be away for a full season, or constant travel to care for the herd, thereby incurring additional costs for secondary housing.

Herders further reported that, nowadays, transhumance is facilitated by various means such as pick-up trucks, tents, beds, hot food, technical clothing, electrical fences, and global positioning systems and global systems for mobile communications (GPS-GSM) devices, which make the journey more bearable. Some herders sleep in nearby villages and return the next morning. In the past, horses, saddlebags, and some food were the only elements for the journey, which was made under much harsher conditions. More people were also needed, as sometimes births occurred along the way, and the absence of electric fences necessitated constant overnight vigilance of the herd.

Although transhumance is very labor-intensive, some herders claim it reduces the herd's annual labor demand, as there is no need for daily feeding. However, the poor condition of some drove roads and infrastructure was reported as adding workload during transhumance. Interviewees mentioned that improved fencing, the closure of agricultural areas, and compliance with drove road width regulations were necessary to make this work more bearable.

Economic and marketing aspects

Almost all the interviewees (99%) focus on meat production, and 10% also orient their systems to producing breeders to sell to other herders. Other products—such as milk, wool, animals for traditional festivities—and tourism, were also mentioned. However, 77% reported having only one productive orientation, while 23% had two. Most herders (78%) sell their products to intermediaries, 22% through cooperatives, and 11% perform direct selling; 78% indicated having only one sales channel, while the rest have from two to four. The final destination of products is often unknown, but almost half of the herders believe that they are exported. Finally, 39% of herders have product certification, mainly related to breed or protected geographical indication (PGI).

On average, lambs were reported to be sold at 18 kilograms (kgs), kids at 9.4 kgs, calves at 228 kgs, and fattened steers at 549 kgs. Lambs received an average price of €58.90 per unit (range: €40–€66) at the time of the interviews. Herders mentioned that national lamb consumption has decreased in recent decades, but demand from Middle Eastern countries has sustained production. Prices for organic producers are not significantly different, and the incentives for this certification are more related to subsidy benefits. The wool market has contracted dramatically for non-specialist producers, and wool has become a residue on many farms. Manure, though, is sometimes exchanged for straw. Milk prices are highly seasonal, with notable drops in spring.

Interviewees mention a lack of recognition of transhumance meat quality by intermediaries and consumers, who prioritize yields and prices, respectively. Some herders belong to associations and cooperatives that work to certify, improve, and sell autochthonous breed products, but efforts concerning traceability and advertising could be improved.

Profitability was reported to be constrained by rising input costs—especially feed, but also pasture, fuel, insurance (some of which is mandatory), sanitary expenses, and stagnant market prices, often set by large lobby groups. Feeding costs are the most variable and fluctuate with weather and market conditions. Although subsidies are economically essential (on average, 49.2% of the herders' incomes came from CAP subsidies), some herders consider them counterproductive because they allow buyers to establish prices, which benefits intermediaries and large sellers rather than the herders themselves. Others believe that subsidies should increase if direct sales cannot be achieved. Interviewees highlighted that subsidy schemes have shifted livestock production toward cattle herding, resulting in the loss of ecosystem services provided by sheep and goats, and that subsidy structures should revert to a production-based approach rather than a land tenure-based one.

Despite increased land vacancy, interviewees reported that access to grasslands is not always ensured, due to rising land prices driven by changes in subsidy schemes (now more closely tied to land tenure) and competition with other land uses such as hunting or renewable energy production.

Adaptations mentioned to achieve profitability include increasing herd size, improving fodder storage, accessing communal pastures, and transitioning to cattle herds to reduce labor requirements. Direct sales through cooperatives or associations are an emerging strategy that can offer better economic returns.

Socio-cultural characteristics

Personal relationship with livestock-keeping. Of the interviewees, 42.9% reported being involved with animals since their earliest memories. Many began transhumant herding due to family heritage, learning from childhood and then adapting their own family dynamics to transhumance. Only a few interviewees were the first generation in their families to practice transhumance.

Most interviewees reported enjoying their livelihood and associated lifestyle, despite its arduousness and laboriousness. They described it as a passion and took pride in being transhumants. Of the things they enjoyed the most, they mentioned the close relationship they established with the animals by taking care of them and watching them grow healthy, improving breeds, overcoming difficult situations such as a complicated birth or a sick animal, ensuring the animals' welfare, traveling with them, and breeding *Mastines*—a Spanish breed of livestock guard dogs. Interviewees also appreciated the peace and beauty of the countryside, enjoying the mountains, taking care of nature, and simply being present in those surroundings, untroubled by the outside world. They also took pleasure in the activity of transhumance; being and sleeping in the open air; the smells, colors, and landscapes; having a healthy life; living and working on their own land; improving the breeds and practices; setting their own schedule and pace of work, goals, and activities; and not having a boss. They preferred this quality of life over conventional employment, which might offer higher incomes but would largely confine them to an office or apartment.

> I always say that I've worked very few times in my life. Because when I work, I enjoy it, so I don't really work…I wake up in the morning and [watch] the colors, the smells, and the spectacle of the surrounding landscape, no matter what season it is. And as you take care of animals every day, you establish a relationship with them. When someone else comes, they get scared, but when I come, here we are, I'm just another cow [laughs]. (27:6)

Interviewees expressed a strong attachment to their territory, preferring to live and work on their own land and in their village, often having spent their entire lives there, and are unwilling to relocate.

Labor conditions and family life. Of the interviewees, 79% indicated livestock as their primary occupation and, on average, they had 39.2 years of experience in animal husbandry. Some herders supplement their income with secondary jobs in forestry, rural tourism, or running a family bar. However, for many, keeping livestock is a full-time commitment, and having another occupation would make it difficult to care properly for their animals.

Transhumants exhibit a non-conventional understanding of work life in which personal and work boundaries blur. Full-time availability is essential, as daily surveillance of animals is required, thereby intertwining work and family dynamics. Working conditions are often described as harsh and exhausting, leaving little free time and having a significant mental burden.

Herders express differing opinions on whether family labor has declined in recent years, but it remains a crucial support. Family labor was reported in 83% of cases, with an average of 2.7 family members, mainly the herder's partner, participating in livestock tasks. External, often foreign, labor was reported in 39% of cases, usually hired for transhumance and farm assistance, but not as permanent employees. Rural exodus and an aging population were cited as reasons for the shortage of skilled labor.

The interviewees occasionally reported that family and hired labor provide them with days off, but proper holidays are rare. Despite the workload, some herders perform transhumance on their own. Children's participation is crucial for generational continuity: even after moving out of their parents' home, they return in the summer to help with the animals, which facilitates knowledge transfer and sharing the passion for the profession. Cooperation among herders, including sharing tasks and supplies and coordinated transhumance, was reported as essential for efficiency, flexibility, camaraderie, and knowledge exchange.

External people, including journalists and photographers, participate in transhumance voluntarily to learn about the profession and to appreciate nature. Some pay to join, with herders managing their needs and offering a rural tourism experience.

Herders stated that harsh weather, precarious accommodation, poor road conditions, long workdays, administrative burdens, and predator attacks negatively impacted their job satisfaction. The last factor increases stress and care hours, which in turn affect profitability and morale, resulting in damage and additional costs. However, herders in some regions, such as *León* province, have developed efficient co-existence practices with predators, thereby reducing conflicts.

The Internet has transformed formalities, with some bureaucratic procedures now being exclusively online. Although this can be a limitation for some herders due to the technological gap, others see it as an improvement.

Women's roles and participation. Women in transhumant livestock activities reportedly engage in similar tasks to men and mentioned that they did not feel discriminated against by male herders. However, women tend to spend fewer hours on livestock due to other employment or greater family care and domestic workloads. Current transhumant men were often cared for by their mothers during childhood, while their fathers were away on transhumance.

We found a gender-based division of labor, with women more frequently handling paperwork and administrative tasks. They also often perform essential activities such as preparing food and supplies for transhumance, diverting traffic, managing animal health and farrowing, caring for animals at the home farm, herding, riding horses, driving pick-up trucks, and setting up night camps. Daughters are typically as involved as sons in transhumance activities, with some of them interested in continuing the family tradition. Nevertheless, some men (albeit only a few) stated that transhumance tasks are too hard for women.

Transhumants reported mistreatment and insults when traveling and crossing roads with animals. Such experiences were more common among women herders, who also noted a lack of acknowledgment of their role as herd leaders.

Social recognition. Interviews revealed that the social recognition of livestock activity, particularly transhumance, is controversial. Many herders contend that society does not understand their work and thus does not value their products and the ecosystem services they provide. They note that although media, public administrations, and the EU offer some discursive acknowledgment, this does not translate into real support. Some herders feel discriminated against and frowned upon for being shepherds and they perceive that some societal views blame them for environmental hazards, climate change, land deterioration, and even animal mistreatment.

Herders see restrictive policies and excessive administrative burdens as indicators of limited social recognition. Examples include the lack of specific subsidies for transhumance and the need for adapted legal frameworks. Herders also highlight that tourists often fail to respect drove roads and shelters and frequently complain about guard dogs. They advocate for exclusive-use pathways and a stronger public commitment to maintaining transhumance infrastructure.

By contrast, some herders contend that the general public values transhumant livestock systems, as evidenced by increased media and social network attention. This acknowledgment is seen nationally but not at the EU level. Herders feel they are valued for their way of life, as evidenced by the growing visibility of extensive livestock practices. Improvements in transhumance infrastructure, tourism, and community activities, including school- and festival-related activities, are also seen as signs of social valuation.

Transhumants are aware of their role as economic drivers, providing direct and indirect livelihoods through product trading, tourism, and hospitality. They are proud to produce high-quality food that has a positive impact on public health, and they perceive that older individuals and rural residents tend to place greater value on transhumant products because of their familiarity with the tradition.

To enhance social recognition of transhumance and its products, herders suggest a social awareness campaign to educate new generations about this culture and its values. They emphasize the need to distinguish and value their products over industrial and synthetic products, and to encourage consumers to choose locally and extensively raised meat. Unity among herders is deemed essential for this effort.

Ecosystem services. Transhumants emphasize wildfire prevention as a key ecosystem service provided by TLSs, noting that rural depopulation and pasture abandonment lead to vegetation encroachment and an increased wildfire risk. They identify forest plantations and the lack of herbivory as primary factors contributing to wildfires and argue that, as with investments in firefighting, extensive livestock systems should be promoted for their preventive benefits.

Herders are aware that the role of their animals in seed dispersal is relevant for biodiversity conservation and ecological adaptation, connecting diverse landscapes and cultures. They are also conscious of the value of their traditional ecological knowledge and the importance of their knowledge heritage and transmission. They also emphasize the importance of preserving autochthonous breeds for their adaptability, resilience, and contribution to agro-biodiversity. However, transhumance-related ecosystem services are not as widely acknowledged or valued by society, media, or policymakers. Herders assert that the contribution of transhumance to nature and society—beyond meat, dairy, and fibers—should be recognized through subsidies and product differentiation.

> Then you do it [the transhumance] again to make it known. And, above all, because the use of mountains is very important…Because the lands in the mountains are becoming deserted, as there is no manure…there are fires because there are no animals to clear and use them. (21:4)

Political and governance characteristics

Communal land governance. Land tenure varies between winter and summer pastures. Winter pastures are predominantly rented (90% of herders), while summer pastures have diverse tenure arrangements: 85% of herders have communal pastures, 36% rented, and 24% owned.

Communal summering lands offer a cost-effective pasture alternative, primarily for herders who live and are registered in the village that owns the pastures. Access requires simple formalities,

including paying a fee and, in some cases, an association membership. Herders from other villages are allowed access only if there is room for more animals.

Management of communal grasslands was said to be overseen by the municipality, herders' commissions, herders' associations, neighborhood councils, or a combination thereof. These organizations collect fees, supervise entry and exit dates, authorize new herders, determine the hectarage that each herder can declare to the CAP, and make operational decisions, often following guidelines established by the herders' council. Expenses such as water provision and infrastructure maintenance are shared. This trust-based system, with minimal conflicts, has remained largely unchanged for decades, with rotating leadership as the main control mechanism. Herders play a significant role in communal management, and some question the need for the involvement of public institutions. In most cases, there are no mechanisms in place to adapt the governance of common lands to social-ecological changes, such as climate change or changes in the type or management of livestock.

Management changes in communal lands were reported to pertain mainly to the challenging, and sometimes controversial, issue of quarantine-sanitary measures, as well as reproductive management and subsidy-related distribution of land areas. Pasture conditions and exclusion of unauthorized herders are rarely monitored, leading to productivity issues as some herders stay year-round, preventing pasture rest. Common grazing relies on self- and collective regulation; sanctions are rarely enforced, although access renewal can be denied in some cases of rule violations.

Political participation. Of all the interviewees, 61% reported participation in unions, 51% in cooperatives, and 80% in associations, with agrarian transformation societies, sanitary defense associations, farmers' unions, and breed associations being the most commonly cited. Despite this formal participation, effective and binding participation is still perceived as low.

Some herders believe that increased collaboration, together with political participation, is necessary to secure better subsidies and to achieve improved economic outcomes through joint projects. However, most interviewees reported that unions and associations are ineffective in addressing the challenges they face and that they are disappointed with collective initiatives. The herders cited conflicts of interest arising from the subsidies unions and associations received, which undermine their lobby capacity. They also highlighted the complexity of the issues that these organizations address, which require multifaceted social processes to include the full diversity of viewpoints.

Groups of transhumant herders

The multivariate analyses enabled us to advance the characterization of TLSs by grouping herders with similar characteristics (descriptive factors). The HCA divided the sample into three groups or clusters (see Table 4 and Figures 2 and 3). The first three components of the PCA accounted for 58.7% of cumulative variance (see Table C2 in Appendix C). The first component (23.8% of total variance) differentiated large farms with high numbers of cattle (LSU), various productive orientations and marketing channels, and transhumance across provinces (positive scores) from those with large sheep LSUs (negative scores). The second component (20.4% of total variance) was associated with

Table 4. Characterization of interviewee groups by hierarchical cluster analysis, Kruskal–Wallis, and chi-squared test.

Variables	K-W/χ^2 observed value	*p* value	Cluster 1	Cluster 2	Cluster 3
Total LSU (average)	9.683	0.008	225.53	227.69	140.74
Sheep LSU (average)	47.800	<0.0001	121.58	1.77	128.83
Goat LSU (average)	21.304	<0.0001	13.46	3.26	4.69
Cattle LSU (average)	51.097	<0.0001	90.50	222.67	7.22
No. of autochthonous breeds (average)	1.330	0.514	1.20	1.59	1.51
No. of productive orientations (average)	8.788	0.012	1.26	1.41	1.09
No. of marketing channels (average)	11.545	0.003	1.12	1.83	1.06
No. of certifications (average)	8.197	0.017	0.38	0.88	0.45
Transhumance on foot (N)	28.724	<0.0001	6	23	34
Wintering and summering areas in different provinces (N)	41.538	<0.0001	18	17	4
Transhumance length (average km)	23.558	<0.0001	459.09	180.52	147.13
Age (average)	7.408	0.025	55.16	47.42	47.38
N			20	27	37

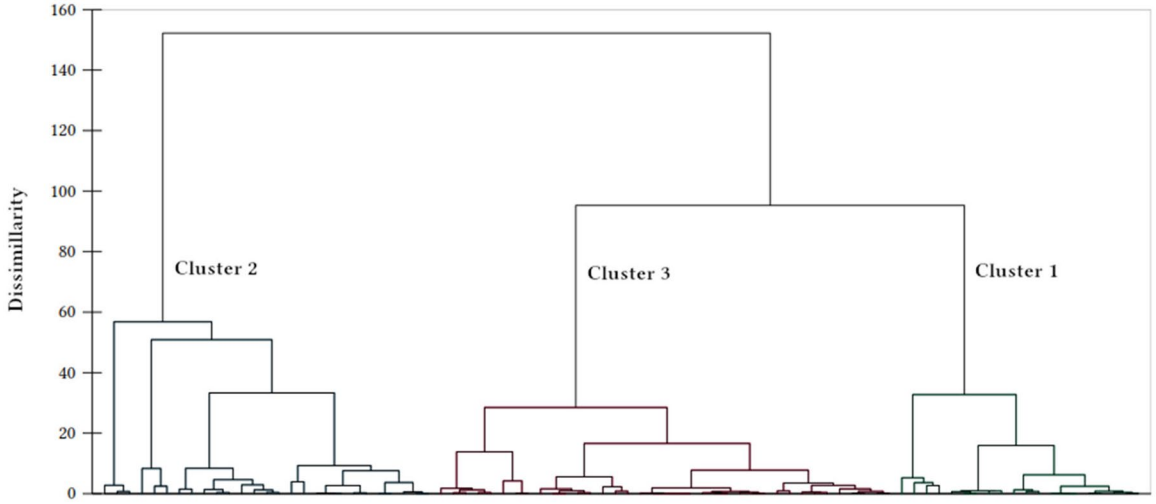

Figure 2. Clusters resulting from hierarchical cluster analysis (HCA).

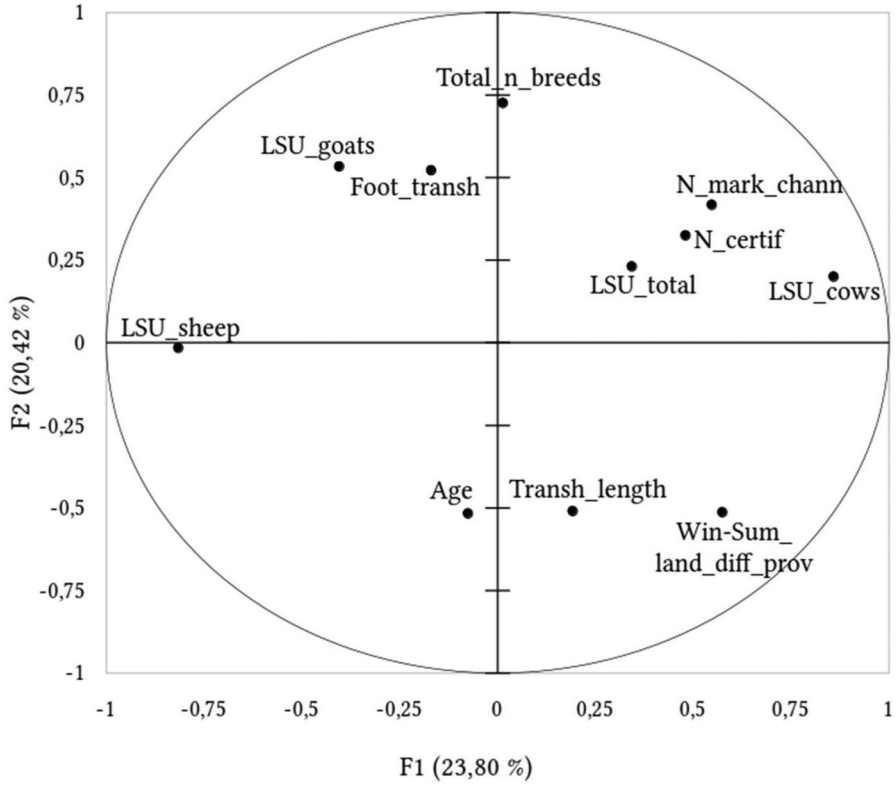

Figure 3. Scatter plot of variables on the first two components of the principal component analysis (PCA) (explaining 44.2% of total variance).

large goat LSUs, breed diversity, and foot transhumance (positive scores), while inter-province transhumance and older herders were associated with negative scores. The third component (14.5% of total variance) was explained by large farms with large sheep and goat LSUs and long transhumance routes (positive scores), and no significant elements with negative scores.

Kruskal-Wallis and chi-squared tests facilitated the description of the three groups and enhanced the profiling of their distinctive features (see Table 5). From the variables with significant results in the multivariate analysis, we found that:

- Group 1 includes the oldest herders (mean age 55.2 years) with mixed-species herds, and the fewest certifications, who conduct the longest transhumance routes mainly by truck. Along

Table 5. Group means and results of multiple pairwise comparisons using Dunn's test.

Variables	Cluster 1 group and mean or α	Cluster 2 group and mean or α	Cluster 3 group and mean or α	*p*-value	$\chi^{2/K}$ (obs)	$\chi^{2/K}$ (cri)
Proportion of lives in livestock breeding	AB / 0.8	B / 0.9	A / 0.6	0.001	13.469	5.991
Total LSU	B / 225.5	AB / 227.7	A / 140.7	0.008	9.683	5.991
Sheep LSU	B / 152.0	A / 15.9	B / 128.8	<0.0001	47.800	5.991
Goats LSU	AB / 33.6	A / 29.3	B / 6.0	<0.0001	21.304	5.991
Cattle LSU	B / 164.5	C / 222.7	A / 53.4	<0.0001	51.097	5.991
Number of productive orientations	AB / 1.3	B / 1.4	A / 1.1	0.012	8.788	5.991
Number of marketing channels	A / 1.1	B / 1.8	A / 1.1	0.003	11.545	5.991
Number of certifications	A / 0.4	AB / 0.9	B / 0.5	0.017	8.197	5.991
Transhumance length (average km)	B / 459.1	A / 180.5	A / 147.1	<0.0001	23.558	5.991
Age	B / 55.2	A / 47.4	A / 47.4	0.025	7.408	5.991
Years in livestock breeding	B / 45.3	AB / 42.8	A / 33.1	0.015	8.433	5.991
Number of livestock species	B / 1.8	A / 1.2	B / 1.9	<0.0001	19.135	5.991
Number of sheep breeds	B / 0.7	A / 0.1	B / 0.8	<0.0001	31.156	5.991
Number of goat breeds	AB / 0.2	A / 0.2	B / 0.6	0.018	8.040	5.991
Number of cattle breeds	A / 0.3	B / 1.3	A / 0.1	<0.0001	42.517	5.991
Participation of women	>	**<***	>	0.044	6.234	5.991
Foot transhumance	**<***	>	**>***	<0.0001	28.724	5.991
Truck transhumance	**>***	**<***	<	<0.0001	20.457	5.991
Wintering and summering areas in different provinces	**>***	>	**<***	<0.0001	41.538	5.991
Wintering land province	*Cáceres, Jaén, Ciudad Real*	*Cáceres, Badajoz*	*Jaén*	<0.0001	86.844	33.924
Wintering and summering areas in the same provinces	**<***	<	**>***	<0.0001	41.538	5.991
Wintering and summering areas in the same region	**<***	**<***	**>***	<0.0001	37.163	5.991
Wintering area region	*Extremadura*	*Extremadura*	*Andalucía*	<0.0001	59.556	26.296
Summering area province	*Teruel*	*Ávila*	*Jaén*	<0.0001	98.838	36.415
Summering area region	*Aragón, Castilla y León*	*Castilla y León*	*Andalucía*	<0.0001	60.150	21.026
Productive orientation: reproduction	>	**>***	**<***	0.014	8.468	5.991
Marketing channel: feedlot	>	**>***	**<***	0.023	7.509	5.991
Marketing channel: butcher's shop	<	**>***	<	0.040	6.458	5.991
Marketing channel: cooperative	**<***	**>***	<	0.004	11.288	5.991
Marketing channel: direct sales	<	**>***	<	0.005	10.566	5.991
Certification: PGI	**<***	>	>	0.023	7.547	5.991
Association membership	**<***	<	**>***	0.003	11.694	5.991

Note: A, B, and C indicate groups that differ significantly from each other. The two-sided Kruskal-Wallis test was used for the overall analysis of variables. For categorical variables, significance levels (α) were assessed using either the chi-squared test or Fisher's exact test. The symbols "<" and ">" indicate whether the row variable has significantly lower ("<") or higher (">") values compared to the column group mean. The symbol "*" denotes statistical significance at $p < 0.05$. The $\chi^{2/K}$ (obs) and $\chi^{2/K}$ (cri) columns refer to chi-squared and K observed and critical values, respectively.

with Group 2, they have the largest herds defined by LSU. The group comprises herders who primarily engage in transhumance, moving from wintering lands in the provinces of Cáceres, Jaén, and Ciudad Real to summering areas in Teruel province and the *Castilla y León* region. This group primarily reflects transhumants who use the *Cañada Real Conquense* drove road. They exhibit low distribution network diversity and sell primarily through intermediaries. As the oldest herders, they have ample experience in livestock breeding. They are not significantly affiliated with associations.

- Group 2 comprises the younger herders, along with Group 3 (mean age of 47.4 years for both), with mainly cattle herds, low species diversity, the most selling channels, and productive orientations and who perform transhumance mostly on foot. Group 2 includes herders who primarily winter in the provinces of *Cáceres and Badajoz* in the *Extremadura region* and summer in *Ávila* province in the *Castilla y León* region. This group largely represents transhumants who utilize the *Cañada Real Segoviana* drove road. Similarly to Group 3, their trips are shorter than Group 1. Despite being relatively young, they have spent the highest proportion of their lives working with animals.
- Group 3 features herders with predominantly sheep herds and with the fewest certifications, selling channels, and productive orientations. They undertake the shortest transhumance routes, mainly on foot, within the same province. They have the smallest herds defined by LSU. The group includes herders who primarily conduct transhumance within *Jaén* province in the *Andalucía* region. They mainly represent the *Pontoneros* group from the *Santiago-Pontones*

municipal area. They are more frequently members of associations compared to the other groups. They are also relatively young and have spent the least amount of time in livestock-keeping.

Characterization of transhumance through an agroecological lens

Following the socio-productive characterization and grouping of the TLSs, we used the results to assess whether, and how, TLSs fulfill AE-Ps. Table 6 presents the 13 principles of agroecology

Table 6. Correspondence of the 13 AE-Ps of the HLPE with the TLSs characterization, including recent trends identified by transhumant herders.

AE-P group	AE-P	Transhumance characterization
Improve resource efficiency	Recycling	Through the direct use of pastures and water resources via partially controlled grazing strategies, transhumance, and pasture rest, transhumant herders close many of the nutrient and biomass cycles they participate in, utilizing mainly local plant and water resources.
	Input reduction	Inherently, transhumant systems tend to be self- and locally sufficient in terms of inputs, particularly feed, which constitutes the largest input. However, interviewees indicate a trend toward greater dependence on feed inputs due to environmental changes, limited land access, and poor pasture conditions, which have also increased reliance on sanitary and genetic inputs. The use of trucks also increases dependence on external inputs.
Strengthen resilience	Soil health	Soil health is normally assured in transhumant schemes, especially with the use of rotational grazing and adequate pasture rest. Exceptions are found in territories where high animal loads are not controlled.
	Animal health	Transhumant herders ensure animal health and welfare through various practices, combined with close monitoring and daily controls, such as a natural grassland-based diet; schedules adapted to weather comfort and food availability; and, for foot transhumants, the relevance of animal welfare in choosing this means of transport.
	Biodiversity	Biodiversity is enhanced through the promotion and care of natural diversity, seed dispersal, and livestock functional diversity by favoring autochthonous breeds. Migration and functional herbivory also promote environmental diversity. The use of trucks, however, reduces TLS's contribution to seed dispersal and overall biodiversity.
	Synergy	Synergy occurs through integration between animals, vegetation, soil, and water. Integration with crops is a common practice in certain regions.
	Economic diversification	Economic diversification is not an inherent characteristic of TLSs but depends on herders' particular selling practices. Strategies that involve direct selling and different productive orientations (Group 2) contribute to diversification. A predominant trend toward reducing income sources was reported. Initiatives to increase the added value of products, such as breed certifications and PGI, were also described, but do not appear to have a strong effect.
Secure social equity / responsibility	Co-creation of knowledge	Horizontal knowledge sharing among herders is a common and active mechanism for intergenerational knowledge transmission. However, the decline of transhumance and the disconnection between territories has likely led to the fragmentation and encapsulation of this knowledge. Only a few interviewees mentioned scientific collaboration.
	Social values and diets	Social values, culture, identity, and tradition are very important aspects of TLSs, and are closely related to its strengths and continuity. These factors were mentioned as foundational to herders' healthy, diverse, and culturally appropriate products. Yet, the transmission of these values to consumers has decreased. Gaps were identified in gender equity, particularly in task distribution and social recognition.
	Fairness	Gaps were found in this principle, especially regarding herders' labor conditions, despite their high job satisfaction. Trade conditions were reported to be quite unequal.
	Connectivity	TLSs are strongly attached to the local economies of inputs. However, in terms of distribution networks, there is a trend of increasing distance from consumers (reduced connectivity). High connectivity remains the exception but is facilitated by direct selling (Group 2).
	Governance of land and natural resources	Common pastoral lands and breed associations are a marked expression of herders' role in managing natural resources. Increasing extension and independence from public administrations in herders' management of common pastures represent visible demands that could improve land governance, together with including herders in decisions on managing drove roads.
	Participation	Except for communal pastures, social organization and effective participation among transhumant herders are poorly developed. Hence, herders' participation in decision-making is very low, even in matters that directly influence them. Some herder groups are more involved in collective initiatives than others.

proposed by the HLPE (2019) and their relation to our socio-productive characterization of TLSs (see Appendix D for a complete description of the HLPE AE-Ps). The agroecological framework also serves to assess the directions that TLSs have taken over decades of change. For instance, key principles such as input reduction, economic diversification, connectivity, governance of land and natural resources, and participation at both farm and agri-food system levels (HLPE, 2019) help evaluate whether their strategies lead to the sustainability of transhumant systems.

Discussion

This work presents a socio-productive characterization of transhumance systems in Spain and evaluates whether, and how, transhumance systems comply with established agroecological principles. Regarding transhumance journeys, we found that the choice between foot and truck transport depends on herd size, with foot transhumance being more economically efficient for large herds. This contrasts with the findings of Velamazán et al. (2024), who found that the means of transport are independent of herd size; however, their reasons reported for choosing on-foot or truck transportation coincide with our findings, including climate conditions, animal-health issues, family or personal matters, and herder's own health. The environmental and social contributions of foot transhumance are critical for the provision of ecosystem services, the maintenance of drove roads, wintering and summering areas, and the preservation of essential knowledge and skills (Velamazán et al. 2024).

Profitability is crucial for the continuity of livestock farming. However, most interviewees reported that the current situation is limiting. Low profitability and labor shortages hinder hiring, prevent improvements in herders' conditions, and, therefore, jeopardize the overall socioeconomic sustainability of operations. The shortage of qualified labor likely stems from unattractive job conditions, combined with broader rural out-migration (Fernández-Giménez and Ritten 2020), among other drivers. In contrast, improved economic outcomes for pastoral projects would promote their co-existence with wildlife and biodiversity conservation (Acebes et al. 2024).

The shift from sheep and goats to cattle herds aimed to reduce labor requirements, especially in herding and predator preventive measures. However, such transformation results in a loss of ecosystem services, as mixed-species herds are reported, both by interviewed herders and in the literature, as the best combination for preventing wildfires and maintaining grasslands (Rouet-Leduc et al. 2021), and also for the regeneration of oak trees in wintering areas (Carmona et al. 2013). Increased subsidy support for predator-prevention measures, such as installing mobile fences, acquiring shepherd dogs, hiring shepherds, rehabilitating shepherds' huts, and other related expenses, can enable the conservation of this type of mixed herd.

Herders identified autochthonous breeds as having significant ecological and adaptive value related to weather, terrain, and predator resistance; however, as reported by Velado-Alonso, Morales-Castilla, and Gómez-Sal (2020), environmental factors and agricultural intensification affect their distribution and subsistence.

Transhumance is indeed closely linked to agroecological principles. Agroecology incorporates animal husbandry through mixed farming, agrosilvopastoral and extensive livestock systems, as part of strategies for sustainable food systems (Ryschawy et al. 2017). Animal scientists have analyzed how agroecology can improve livestock systems. For instance, Dumont et al. (2013) proposed five principles for integrating agroecological practices into livestock-farming systems: (1) improving animal health through management practices, (2) reducing production inputs, (3) minimizing pollution by optimizing the metabolic functioning of farming systems, (4) enhancing diversity within animal-production systems to strengthen their resilience, and (5) preserving biological diversity in agroecosystems by adapting management practices. Our characterization, along with its contrast with the AE-Ps, shows that these five principles are integral to TLSs. We find that the TLS principles and values inherently align with AE-Ps, rather than merely borrowing from them to make improvements. In fact, we generally observed that those AE-Ps linked to agroecosystems, such as synergy, soil and animal health, recycling, biodiversity, and input reduction, are commonly addressed by TLSs. This is not surprising, since TLSs are ancient systems that, as agroecological farming systems, result from the co-evolution of humans and nature, achieving

equilibrium (Beckmann and Garzón Heydt 2009). Additionally, transhumant values, practices, and discourses resist the trend toward industrialization in livestock systems and agriculture, paralleling the foundational principles of agroecology (Sevilla Guzmán and Woodgate 2012).

However, external ecological and social factors, such as climate change and public policies, are driving transformations that significantly impact transhumance and its alignment with AE-Ps. These factors are notably increasing dependence on external inputs (e.g., feed and transport), which may negatively impact principles such as recycling and synergy. The CAP subsidy scheme has also significantly contributed to the decline of traditional transhumance practices and grasslands in some European regions (Fernández-Guisuraga et al. 2022), with potential negative impacts on most of the listed AE-Ps. Spanish transhumants cite CAP subsidies as a significant driver of intensification and the decline of traditional pasture uses and sheep- and goat-herding, a trend that is only reversed in areas providing substantial additional subsidies for transhumants (Fernández-Guisuraga et al. 2022). Policies promoting ecosystem services, including their recognition and compensation under the CAP, represent valuable support mechanisms for family farms and could reverse the intensification and abandonment of traditional pasture (Guzmán et al. 2022). The long-term exclusion of transhumant sheep also negatively affects soil function and promotes the encroachment of woody vegetation in grasslands (Carmona et al. 2013; Fernández-Guisuraga et al. 2022), thereby impacting the principle of soil health. This may partially explain the interviewees' perceived link between reduced animal load and decline in pasture quality.

The social values and diets principle aligns well with TLSs, particularly in fostering food systems rooted in culture, identity, and tradition. However, achieving gender equity remains an unmet challenge, with limitations to female participation, as shown especially in Group 2 of the cluster analysis. Rural migration has been more pronounced among women than among men (Camarero and Sampedro 2016). As noted by Fernández-Giménez, Oteros-Rozas, and Ravera (2021), women require collaboration networks to access the extensive livestock sector, increase their participation, and address specific needs. Women's labor in TLSs is crucial but often underrecognized, lacking support and decision-making power, which must be improved to enhance TLS performance in Spain, in line with this principle, and to promote innovation and adaptation (Fernández-Giménez, Ravera, and Oteros-Rozas 2022). The analyzed TLSs also revealed an unequal distribution of work tasks on the farm, both with animals and at home, consistent with Contzen and Forney (2017) findings that a "traditional" labor distribution persists in family farming, while new arrangements are emerging that could enhance gender equity. The AE-P of land and natural resource governance, through the management of common lands and the promotion of autochthonous breeds, aligns well with agroecological values. However, common grasslands face threats from both encroachment and overuse, partly due to the rigidity and lack of innovation in customary governance arrangements.

For the principles linked with the food system, such as economic diversification or connectivity, we observed no clear trends; the findings vary by case and are thus context-dependent. For instance, Group 2, characterized by direct selling and hence higher connectivity, adheres more closely to this principle than Group 3, which primarily sells through intermediaries and has the least diverse marketing channels and productive orientations. The same applies to the participation principle, where Group 3 exhibits relatively high associativity, which, combined with the herders' younger age, may help improve their limited economic diversification. Group 1 shows limited membership in associations. This evidence, along with general political disaffection revealed in transhumants' discourses, hinders their involvement in critical issues that directly affect them, such as sanitary regulations, subsidy schemes, and governance of drove roads. Increased participation could also facilitate collective marketing initiatives, thereby improving farm profitability and adherence to the fairness principle. Breed associations and groups related to communal lands are fulfilling this role to some extent and could extend their functions to defend the territorial footprints of their products and develop alternative processing and marketing plans (Fernández-Guisuraga et al. 2022). Control of their marketing, distribution, communication, and advocacy activities is crucial for enabling agroecologically oriented farmers to develop their own collective economic structures (López-García and Carrascosa-García 2023).

With this in mind, groups of herders associated with a territory could develop and control new economic initiatives or revitalize existing ones, retaining control of these factors to achieve better

financial outcomes from their livestock projects. Indeed, within the TLS context examined here, fairness is likely the principle with the lowest correspondence to agroecology. Consequently, this represents a potential focus for policy innovations to enhance the agroecological performance of TLSs, particularly regarding labor conditions and unequal trading practices. This principle states that agroecology supports "dignified and robust livelihoods…based on fair trade, fair employment and fair treatment of intellectual property rights" (HLPE 2019). However, our analysis indicates that herders perceive their livelihoods as neither robust nor dignified.

Our findings on the enablers and barriers influencing the adoption of agroecological principles in TLSs align with those reported by Dumont et al. (2025), particularly regarding inadequate infrastructure, outdated policy frameworks, and cultural constraints as barriers, and positive image among citizens and consumers, cooperation networks, direct sales, and short distribution chains as key enablers.

Our findings regarding herders' perceptions of economic efficiency align with those of Fernández-Giménez and Ritten (2020), who report that transhumance is more profitable than stationary semi-extensive operations, with profitability increasing in proportion to herd size. They also highlight that transhumance on foot is more resource-efficient than by truck and offers additional advantages. Furthermore, they note that technology enhances working conditions for transhumant herders by reducing labor requirements. A notable finding that warrants further research is the connection between technology and the principle of fairness. Interviewees acknowledge their improved material conditions, especially during transhumance, thanks to tools such as pick-up trucks, electric fences, GPS-GSM devices, and mobile phones, which reduce labor needs. The use of mobile phones, particularly for connecting to virtual social networks and information channels, has enabled transhumant herders to stay updated, make more informed decisions, undertake joint actions, and maintain better contact with their families and friends (Vidal-González and Fernández-Piqueras 2021). However, technology is a controversial topic in agroecology research, as it may increase dependence on external inputs and concentrate power among technology providers (Anderson and Maughan 2021). This is an ongoing debate on agroecological transitions to which TLSs can contribute (Migliorini et al. 2020).

Conclusion

Our study includes a large sample of transhumant herders in Spain; however, the lack of a comprehensive national census of herders makes it challenging to accurately assess the representativeness of our findings. Additionally, we were often limited to conducting a single interview per farm, thereby capturing the perspective of just one family member (usually a male) and omitting potential insights from others, particularly women. Furthermore, the design of our study limited the possibility of identifying and relating the trends and narratives of the characterization with the groups of transhumant herders.

Through socioeconomic characterization, we have demonstrated that TLSs inherently adhere to several AE-Ps, especially those related to agroecosystems. However, external driving forces, such as agricultural and trade policies, sociodemographic trends, and climate change, are weakening the alignment with the other principles. Principles linked to food systems or those with a strong social component show less consistent adherence, as they depend on social and political contexts. The three groups of TLSs identified in our study exhibit varying levels of adherence to social principles, such as participation, connectivity, and economic diversification. Notably, fairness is the AE-P with the least adherence among TLSs, primarily due to low profitability, strenuous labor conditions, and insufficient support from society and public administrations.

The lack of a specific regulatory framework to support, protect, and promote transhumance poses a significant challenge. Despite efforts such as the Proposal for a National Strategy for Extensive Livestock from nongovernmental organizations (NGOs) and herders' associations (Zabalza et al. 2021), there is a pressing need for public administrations and other organizations to commit themselves to strategies that enhance social recognition of the high quality of transhumance products in addition to the wider value and benefits that TLSs provide.

TLSs in particular and pastoral systems in general are endangered, despite exemplifying practices and providing key insights for transforming food-production systems, strengthening food security, and maintaining vital environmental knowledge. In recognition of this, the United Nations declared 2026 the International Year of Rangelands and Pastoralists (IYRP) (FAO 2022). There is a need for further research and greater recognition of TLSs, with a specific focus on issues crucial to their continuity and promotion, such as administrative and regulatory limitations, trade and profitability constraints, and environmental conflicts.

Notes

1. *Dehesas* are anthropogenic agricultural landscapes for livestock and multifunctional use on which at least 50% of the surface is covered by pasture and scattered adult trees – usually from *Quercus genus* – occupy between 5% and 60% of the surface with the projection of their canopies.
2. The council of *La Mesta* was established in 1273 by King Alfonso X. It united all the herders from *León* and *Castilla* in one association, granting them rights of passage, grazing, and various privileges.
3. Three interviews could not be transcribed due to environmental situations that affected recording quality. Although we did not use these interviews in the content analysis, we did include the interviewees' data in the descriptive and quantitative analysis.

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Appendices

Appendix A. Interview protocol and script

TRASCAR interview

First call protocol

- Presentation of the interviewer: name, project, interview objectives.
- Confidentiality clause: Interviews will be recorded and transcribed. Information will be available for interviewees and can be withdrawn from the project at any time. Information will be used anonymously for scientific publications and a dissemination report.
- Interviewer contact information.
- Appointment for the interview.

Second call protocol

- Brief review of the project presentation and interview conditions.
- Explicit consent for recording.
- Start of recording.

Identification of each interview

- ID, interviewer's name, date and time, length (at the end), interviewee's name, interviewee's contact information, interview format (phone, in-person), location.

Personal and family relationship with livestock and transhumance

- How did you start in livestock farming? Were your ancestors herders? If so, who were they (grandparents, parents, etc.)? Do you have descendants who will continue with livestock farming? Would you like them to do it?
- Are you happy to do livestock farming? What do you like most about livestock farming? And the least?
- Why do you practice transhumance? Why not sedentary? What are the advantages of being transhumant? What are the drawbacks?
- Have you always been transhumant? If you have changed, why did you do so?
- How do you think society values transhumance?

Working livestock

- For how many years have you been a herder?
- Is livestock farming your main work?

- How many hours a week do you spend working with livestock, approximately?
- How many members of your family work with livestock?
- Which family members participate in livestock tasks? In which tasks? (herd handling; animal health; support in birthing; handling of the grass, feed, and other supplies; administrative and commercial procedures, etc.).
- Who else is part of your family group?
- Do you have any employees? For which tasks? For how many hours per day?

Economic-productive characterization

- How many animals do you have now? (no. of animals by species and breeds).
- Compared to 10 years ago, has your census increased, decreased, or remained constant?
- What is your main productive orientation (meat, dairy, wool, fur, for reproduction, etc.)?
- What other products or activities do you sell (wool, manure, rural tourism, cheese, cold cuts, leather, spun wool, clothing, crafts, etc.)? Which ones are for your own family's consumption?
- Who do you sell to (intermediaries, cooperatives, other herders, direct to consumers, etc.)?
- At what weight do you sell animals?
- How many birthing seasons do you have each year? When (months)?
- In your opinion, which birthing season offers the best meat quality?
- Which birthing season offers the greatest profitability (cost/benefit)?
- Weight and price/kg for each birthing season. If there are differences, why?
- Do you fatten animals on the farm?
- Do you know the final destination of your production?
- Do you have any certifications? If so, which one/s?
- Do you identify any problems in marketing?
- How can the marketing of transhumant meat be improved? Would a certification be of interest to you?

Transhumance characterization

- How do you carry out transhumance (on foot, by truck)? Why? Would you like to change?
- If done on foot, how would you evaluate the conservation condition of the livestock roads?
- Which are your summering and wintering areas? (name, municipality, surface [ha], land tenure [communal, rent, property, other], grazing hours per day, feeding supplementation, costs)
- What transhumance route do you use? Please specify (name of drove roads or passage zones).
- Approximately what distance do you travel between summer and winter pastures?
- What are the approximate expenses per trip?
- Do you coordinate with other herders for the journey? With whom? How?
- On what date do you move to summer/winter pastures? Why on that date? Are dates variable? If dates are variable, what do they depend on?
- How many people participate in transhumance? What does each one do?
- How many of them are women? What are their tasks? Are there differences in their work compared to what men do?

Technology

- Do you use any new technology in your work? Which one(s) (mobile phones, pick-up trucks, GPS, ultrasound machines, etc.)? For what purpose?
- What benefits does it offer you? How does it help you in your work?
- What annual cost do these technologies entail?
- Are you considering using any in the future? Why? If so, which ones?

Socioecological challenges of extensive livestock and transhumance

- For you, what are the biggest challenges for extensive livestock farming in Spain?
- What do you think about the relation between the following issues and extensive livestock?
- Hunting (wild dogs, competition for grassland resources, diseases, etc.).
- Agriculture (agrochemicals, invasion of drove roads, etc.).
- Dogs (hikers, lawsuits, expenses, etc.).
- Protected areas/conservation laws.
- For you, what are the biggest challenges faced by transhumance in particular?

Perception, impacts of, and adaptations to global change

- What changes in the last 10 years have influenced/are influencing your livestock practices? Please specify: ecological/environmental, political/regulatory/institutional, social/cultural, economic/financial, demographic/family.
- How has each one of them influenced your livestock practices?
- Besides changes in livestock and field management practices, what have you had to do/are you doing to adapt to these changes?
- Do you perceive climate change? How do you notice it? How does it affect your livestock farm?
- Did the COVID-19 pandemic affect you in any way in 2020? If so, how?

Co-existence with wildlife

- Of the wild species you find in the countryside, which ones draw your attention? Why?
- How is your relationship with wild herbivores?
- Are there wolves in your territory? Do you think any form of co-existence with this species is possible? If so, how? What measures do you take/can be taken to improve this co-existence?
- Are there bears in your territory? Do you think any form of co-existence with this species is possible? If so, how? What measures do you take/can be taken to improve this co-existence?
- What do you do with dead cattle?

Social organization

- Do you belong to any agricultural union?
- Do you belong to any cooperative? If so, what do you sell at the cooperative?
- Do you belong to any other type of organization or group of herders? What is the main objective of that organization? In which territory does it operate?
- Do you participate in any political organization?
- Do you use common land pastures? If so, who can use them? How do you decide who can use them? How do you access them? Are there limitations on livestock load? What happens if someone does not comply with the rules? Is the condition of the pastures monitored? How? Are there conflicts? If so, which ones? How are they managed? Have there been changes to the management system in the last 10 years? What do you think about this system?

Socio-demographic information

- Gender, age, years you have lived in the territory.
- What proportion of your family income comes from livestock? (%).
- Of these, approximately what proportion corresponds to CAP subsidies? (%).

Improvements

- What do you think can be done to improve the situation of extensive livestock farming in Spain?
- What can the herders improve?

- If you were not a herder, what would you like to have done professionally?

Closing protocol

- Acknowledgments.
- Ask for contacts of other herders from the territory.
- Ask for suggestions, comments, evaluation of the experience, etc.
- Ask if he/she wants to receive the transcript of the interview and project results, and by which means (phone, email, post).

Evaluation of the interview

- Interviewed person's attitude.
- Degree of understanding of the interview questions.
- Interruptions or problems that may have occurred during the interview.
- Is this a key informant, it is someone with a lot of knowledge? Why?
- Other general impressions.

Appendix B. List of content-analysis codes

Table B1. Content-analysis codes.

Code	Group
Communal pastures entry	Communal pastures
Communal pastures load	Communal pastures
Communal pastures management	Communal pastures
Communal pastures sanctions	Communal pastures
Communal pastures surveillance	Communal pastures
Livestock productive characterization	Economic-productive characterization
Marketing characterization	Economic-productive characterization
Profitability and costs	Economic-productive characterization
Personal relationship with livestock keeping	Personal relationship with livestock keeping
Social recognition of transhumance	Personal relationship with livestock keeping
Ecosystem services	Socioecological challenges
Advantages of transhumance	Transhumance characterization
Animals movement	Transhumance characterization
Arrival/departure dates	Transhumance characterization
Breeds	Transhumance characterization
Drove roads	Transhumance characterization
Technology	Transhumance characterization
Transhumance and grazing characterization	Transhumance characterization
Transhumance support staff	Transhumance characterization
Women's participation	Transhumance characterization

Appendix C. Description of the study variables and PCA values

Table C1. Description of the study variables. DA: Quantitative descriptive analysis, MA: Multivariate analysis.

Variable	Description	Analysis where included	Mean / yes	SD	Max.	Min.
Years_livest	Years spent by the herder working with livestock.	DA / MA	39.2	15.8	73	1
Livest_main	Livestock is the main productive activity	DA	66	*Dichotomous variable*		
N_famil	Number of family members involved in livestock activities.	DA	2.7	1.4	7	1
Women_part	Women's participation in livestock activities.	DA / MA	31	*Dichotomous variable*		
Employees	Hired labor for livestock activities	DA	24	*Dichotomous variable*		
LSU_tot	Total number of livestock units (LSU)	DA / MA	188.9	142.2	777	9
LSU_sheep	Sheep LSU	DA / MA	129.4	75.4	390	1.2
LSU_goats	Goat LSU	DA / MA	13.3	37.0	225	0.3
LSU_cattle	Cattle LSU	DA / MA	188.1	174.5	740	9
Livest_type	Species of livestock animals kept	DA / MA		*Nominal variable*		
Aut_breeds	Number of autochthonous breeds	DA / MA	1.9	1.1	6	1
Prod_orient	Productive orientation of the herd	DA / MA		*Nominal variable*		
N_prod_orient	Number of productive orientations of the herd	MA	1.2	0.5	2	1
Mark_chann	Marketing channels for products	DA / MA		*Nominal variable*		
N_mark_chann	Number of marketing channels for products	MA	1.3	0.7	3	0
Certif	Certifications of products	DA / MA		*Nominal variable*		
N_certif	Number of certifications of products	MA	0.7	0.7	3	0
Trans_foot	Transhumance made on foot	DA / MA	63	*Dichotomous variable*		
Trans_truck	Transhumance made by truck	DA / MA	25	*Dichotomous variable*		
Win_province	Province where wintering area is located	DA / MA		*Nominal variable*		
Win_region	Spanish Autonomous Community where wintering area is located	DA / MA		*Nominal variable*		
Sum_province	Province where summering area is located	DA / MA		*Nominal variable*		
Sum_region	Spanish Autonomous Community where summering area is located	DA / MA		*Nominal variable*		
Dif_prov	Wintering area is in a different province to summering area	DA / MA	38	*Dichotomous variable*		
Same_prov	Wintering area is in the same province as summering area	DA / MA	41	*Dichotomous variable*		
Same_region	Wintering area is in the same Spanish Autonomous Community as summering area but in a different province	DA / MA	3	*Dichotomous variable*		
Win_arrival	Wintering area arrival date	MA	26 Nov	19.1	30 Dec	30 Aug
Win_depart	Wintering area departure date	MA	30 May	17.8	5 Jul	15 Apr
Sum_arrival	Summering area arrival date	MA	8 Jun	17.4	15 Jul	25 Apr
Sum_depart	Summering area departure date	MA	17 Nov	23.3	30 Dec	30 Aug
Duration_foot	Foot transhumance duration (days)	DA	9.6	7.5	30	1
Duration_truck	Truck transhumance duration (hours)	DA	7.8	4.4	12	2
Length_foot	Foot transhumance distance (km)	DA / MA	177.7	121.7	535	11
Length_truck	Truck transhumance distance (km)	DA / MA	333.6	204.6	600	50
People_transh	Number of people assisting the transhumance	DA	4.2	2.8	20	1
Union	Participation in labor unions	DA	31	*Dichotomous variable*		
Cooperative	Participation in cooperatives	DA	27	*Dichotomous variable*		
Association	Participation in associations	DA / MA	52	*Dichotomous variable*		
Gender	Interviewee's gender	DA		*Nominal variable*		
Age	Interviewee's age	DA / MA	49	11.0	73	26
Years_area	Years living in the area	DA	43.1	14.2	64	5
Livest_income	Percentage of income coming from livestock	DA	94.1%	13.8%	100%	50%
CAP_income	Percentage of livestock income coming from CAP subsidies	DA	49.2%	16.2%	90%	10%

Table C2. Values derived from PCA.

	F1	F2	F3
Own value	2.618	2.247	1.591
Variability (%)	23.789	20.425	14.467
Cumulative %	23.789	44.223	58.690

Appendix D. Agroecological principles of the HLPE

Table D1. Full description of the agroecological principles of the HLPE.

AE-Ps group	AE-Ps	Description
Improve resource efficiency	Recycling	Preferentially use local renewable resources and close, as far as possible, resource cycles of nutrients and biomass.
	Input reduction	Reduce or eliminate dependence on purchased inputs and increase self-sufficiency.
Strengthen resilience	Soil health	Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and enhancing soil biological activity.
	Animal health	Ensure animal health and welfare.
	Biodiversity	Maintain and enhance species diversity, functional diversity, and genetic resources and thereby maintain overall agroecosystem biodiversity in time and space at field, farm, and landscape scales.
	Synergy	Enhance positive ecological interaction, synergy, integration, and complementarity among the elements of agroecosystems (animals, crops, trees, soil, and water).
	Economic diversification	Diversify on-farm income by ensuring greater financial independence and value addition opportunities while enabling responses to consumer demand.
Secure social equity / responsibility	Co-creation of knowledge	Enhance co-creation and horizontal sharing of knowledge, including local and scientific innovation, especially through farmer-to-farmer exchange.
	Social values and diets	Build food systems based on the culture, identity, tradition, social, and gender equity of local communities that provide healthy, diversified, and seasonally and culturally appropriate diets.
	Fairness	Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment, and fair treatment of intellectual property rights.
	Connectivity	Ensure proximity and confidence between producers and consumers by promoting fair and short distribution networks and by re-embedding food systems into local economies.
	Land and natural resources governance	Strengthen institutional arrangements to improve, including the recognition and support of family farmers, smallholders, and peasant food producers as sustainable managers of natural and genetic resources.
	Participation	Encourage social organization and greater participation in decision-making by food producers and consumers to support decentralized governance and local adaptive management of agricultural and food systems.