



Patterns and Relations in Small Ruminant Systems in Northern Jordan

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ABSTRACT

Background: This study examines small ruminant production systems in Northern Jordan, where they play a crucial role in agriculture and support local livelihoods.

Methods: A survey of 290 small ruminant holders was conducted from April 2022 to August 2023, employing descriptive and multivariate analyses using XLSTAT and TANAGRA software to explore socioeconomic traits, management practices and feeding strategies related to the production period of 2021.

Result: The results showed that there was variability in small ruminant production systems. More than half of small ruminant holders utilized semi-extensive methods and focused on cash sales. Factors such as labor distribution, animal replacement strategies and housing practices differed among climate regions and governorates. The typological analysis revealed clusters of small ruminant holders based on criteria such as labor management (4% of small ruminant holders), animal replacement strategies (42%), market-oriented production systems (6%), extensive commercial sheep farming (30%) and experienced farmers with medium flock sizes (17%). This study provides valuable insights into the small ruminant production systems in Northern Jordan, informing future strategies for enhancing productivity and sustainability in the region.

Key words: Farming practices, Small ruminants, Sustainability, Typological analysis.

INTRODUCTION

Small ruminants, including sheep and goats, are vital components of agricultural systems worldwide, particularly in arid and semi-arid regions where they efficiently convert low-quality feed into valuable protein sources (Sejian *et al.*, 2021). The socioeconomic significance of small ruminant husbandry is particularly pronounced among landless individuals and small-scale farmers, serving as a primary source of livelihood and nutritional support (Sahoo, 2023). These animals not only provide essential products such as meat, milk, skin, wool and manure, but they also contribute to the resilience of farming communities in challenging environments (Shivakumara *et al.*, 2020).

In Jordan, small ruminant production is a cornerstone of the agricultural sector, especially in the northern regions where over 35% of the country's small ruminant population is concentrated (Jordanian Ministry of Agriculture, 2022). Despite their importance, knowledge regarding specific small ruminant production systems in Northern Jordan remains limited. Previous research in areas like the Middle Badia has highlighted the impact of feed resources and economic viability, yet comprehensive analyses of the diverse production systems in Northern Jordan are still lacking (Abu-Zanat *et al.*, 2005).

Given the variability in practices and socio-economic conditions affecting small ruminant farmers, understanding the distinct characteristics and relationships within these production systems is crucial for devising effective strategies for enhancing productivity and sustainability.

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This study aims to fill this knowledge gap by analyzing small ruminant production systems in Northern Jordan. By employing multivariate analysis, this research focuses on household socioeconomic traits, management practices, feeding strategies and breeding methods. The insights gathered will not only inform sustainable development initiatives but also provide actionable recommendations for improving the productivity and profitability of small ruminant production in the region, ultimately benefiting farmers and enhancing the local economy.

MATERIALS AND METHODS

The study was conducted in Northern Jordan (32°25'6.96"N, 38°18'59.66"E) in four governorates with varied geography and climates, including Mediterranean climate in Irbid, Jerash and Ajloun and desert climate in Mafraq. The area covers 28,943 km² and is home to 3,297,300 people (Jordanian Department of Statistics, 2024). Data on small ruminant production systems were collected during the survey period from April 2022 to August from 290 holders, selected using stratified random sampling (Mashaal, 2018). The survey examined social and demographic profiles, labor practices, herd characteristics and feeding and management practices related to the production period of 2021. Statistical analysis included descriptive and multivariable analyses to investigate characteristics of small ruminant production systems in the region.

Descriptive statistics were used to summarize the production systems, while ANOVA and Chi square tests were used to compare variables among different climate regions. Multiple correspondence analysis (MCA) and Hierarchical Agglomerative Clustering (HAC) were utilized to identify key factors driving variability in the data and group similar production systems together. Dendrograms were used to visually represent relationships between production systems and variables.

RESULTS AND DISCUSSION

Small ruminant production systems: General descriptive

Small ruminant populations in different governorates of the study area (Irbid, Jerash, Ajloun and Mafraq) distributed among 3614, 1136, 831 and 5824 animal holders respectively are presented in Fig 1.

Small ruminant production systems in Northern Jordan were characterized by a majority of holders falling within the middle-age group (40-59 years) at 58%. Educational levels vary between climatic regions, with higher rates of illiteracy observed in Mafraq (47%) compared to the Mediterranean Governorate (<3%). Most farmers (75%) had less than a high school education and had an average of

over 31 years of experience in small ruminant production. Small ruminant production was the primary source of cash income for 70% of farmers, with the majority engaging in a mixed system that includes small ruminants and crops. Labor of small ruminants was primarily carried out by family members, accounting for 69% of the total effort.

The primary source of small ruminants was through herders' own animals (88% of the total holdings). The average total holding/farmer varies significantly among climatic regions, with Mafraq Governorate having the highest average holding per farmer (516 head/ farmer). Small ruminant production was primarily conducted by medium holders (own 100-500 animals). The Awassi breed dominated the sheep population in Northern Jordan, while the local Baladi breed was the predominant goat breed. Other sheep breeds presented in the study area included Israeli (improved Awassi, 9%), Chios (2.2%), Assaf (1.7%), Hamadani (1%), Najadi (0.2%) and Erabi (Chuffali) sheep (0.2%; Fig 2a). Additionally, other goat breeds identified included the Desert (7%), predominantly located in the eastern region of Mafraq Governorate, Shami (3%), Albino (2%), Hijazi (1%) and Indian (0.2%) goat breeds (Fig 2b). The primary objective of keeping small ruminants was to generate cash income (46%), although there were variations in objectives between different regions, with some focusing more on milk production. The majority of farmers (50.0%) utilizing semi-extensive methods, only 7.6% of farmers practiced intensive methods. Variations were observed among climate regions, with Ajloun having the highest proportion of semi-extensive farming at 62.5% and Irbid having no intensive production systems at all.

Small ruminant production systems: Typological analysis

By utilizing (MCA) and (HAC) analysis of 51 variables, these variables were divided into 36 main variables are classified into 14 themes based on the relationship between the variables (Table 1). Through this analysis, the variables were clustered into five distinct groups (Fig 3,4).

The first group (G1) focuses on the management of labor in small ruminant production systems. This group includes 11 farmers (4% of the total sample), with a majority

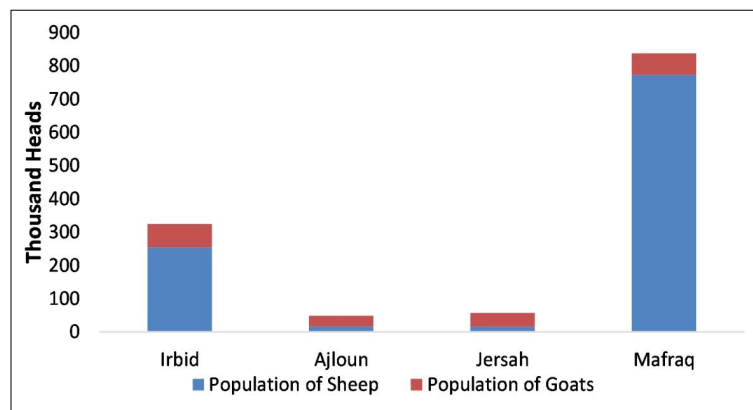


Fig 1: Small ruminants' populations in the Northern Jordan, year 2021.

located in Mafrq governorate. All farmers were in the middle age. They typically hire 2 full-time workers and 2 part-time workers, with 46% also employing family members. Small ruminant production was the main source of income for 64% of farmers, who had an average flock size of 450 animals. Most farmers use semi-extensive production systems.

The animal replacement strategy is the main criteria for the second group (G2). This group, consisting of 123 farmers (42.4% of the total sample), focuses on replacing animals by purchasing new ones. These farmers were evenly distributed across climate regions, with an average age of 52 years, had an average of 30 years of farming experience. Most farmers (60%) engaged in both crop cultivation and raising small ruminants, with small ruminant

production being the main income source for 63% of them. The primary purpose of raising small ruminants varies, with 40% focused on milk production, 37% on cash sales and 23% on both. The majority of farmers (86%) replaced animals from their own stock for sustainability, while 14% purchased new animals. Most farmers utilized a semi-extensive production system. Additionally, over 85% provided supplemental feed in the form of trees' trimming, shrubs and rain-fed residues.

The third group (G3) is characterized by market-driven production systems, which consists of farmers with moderate experience in small ruminant production who operate under intensive production systems and buy their animals as a source of small ruminants. 6% of total farmers are in this group, with 55% located in Mediterranean regions.

Table 1: Classification of variables in small ruminant production systems in Northern Jordan.

Variables	Class	Variables	Class
Main variables			
Experience	5-10 years	Herd type	Sheep
	10-30 years		Goats
	>= 30 years		Sheep and goats
Type of work	Crop + small ruminant	Purpose of raising animals	Milk production
	Small ruminant		Cash sale
Labor	Family	Production system	Milk production and
	Family and paid-workers		Extensive
	Paid-workers		Intensive
Paid full-time employment	Absence	Source of replacement	Semi-extensive
	Presence		Purchase new animals
Paid part-time employment	Absence	Additional nutrition (trimming of trees and shrubs)	Purchase new animal and sustainability out of stock
	Presence		Sustainability out of stock
Main source of income	Small ruminant	Additional nutrition (rain-fed residues)	Yes
	Outside source		No
Source of animals	Inheritance	Education level	Read and write
	Purchase + inheritance		Less than high school (Tawjihi)
	Purchase		High school (Tawjihi)
Herd size	Large (>=500)	Farmers Age	BCs
	Medium (100-500)		Higher education
	Small (<=100)		
Supplemental variables			
Geographical region	Mediterranean	Governorates	
	Saharo-Arabian		
Governorates	Ajloun	Farmers Age	Young adults (18-39 years)
	Irbid		Middle-age (40-59 years)
	Jerash		Old (60 and above)
	Mafrq		

*Key variables of each group.

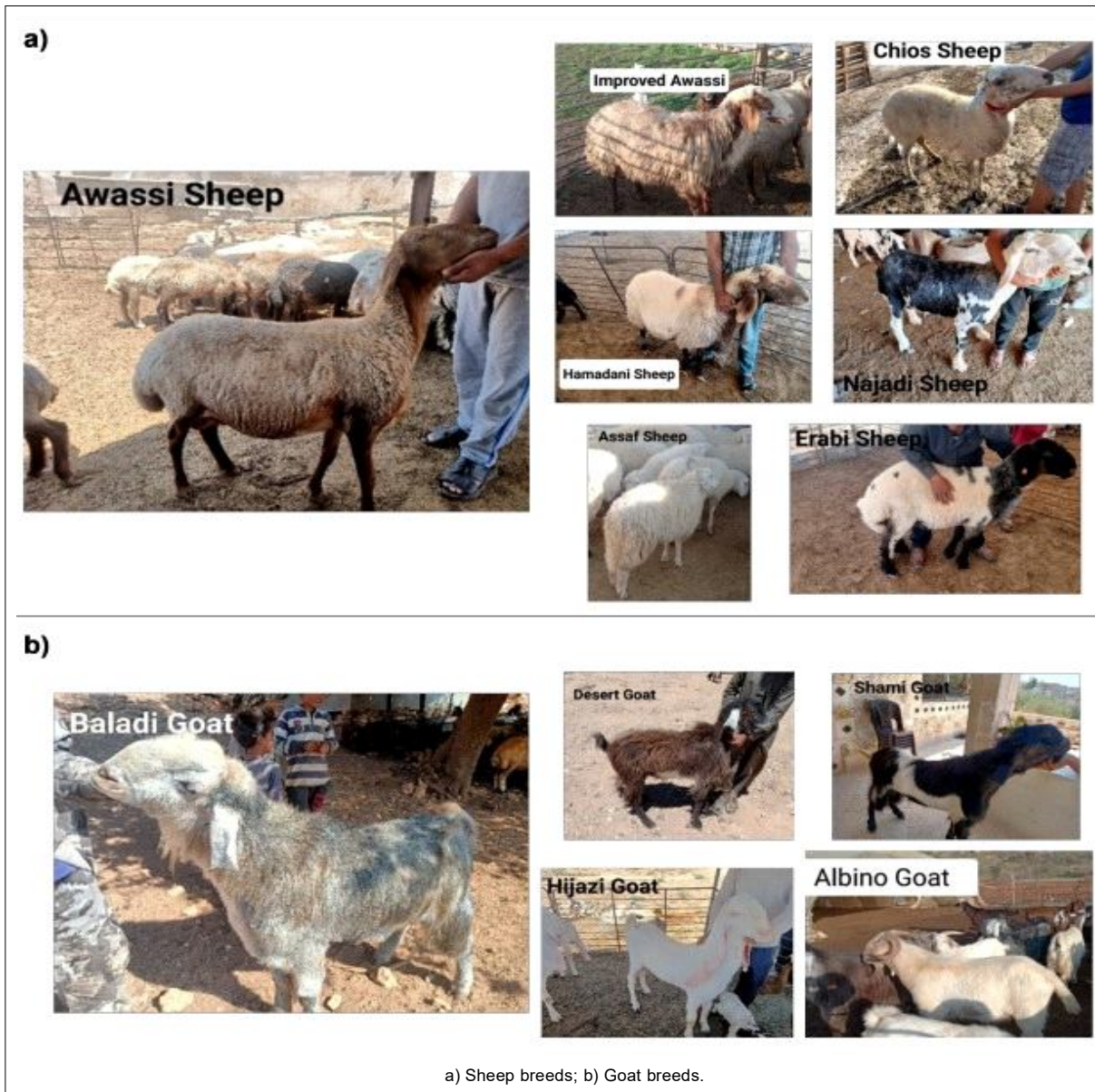


Fig 2: Some breeds of small ruminants found in Northern Jordan.

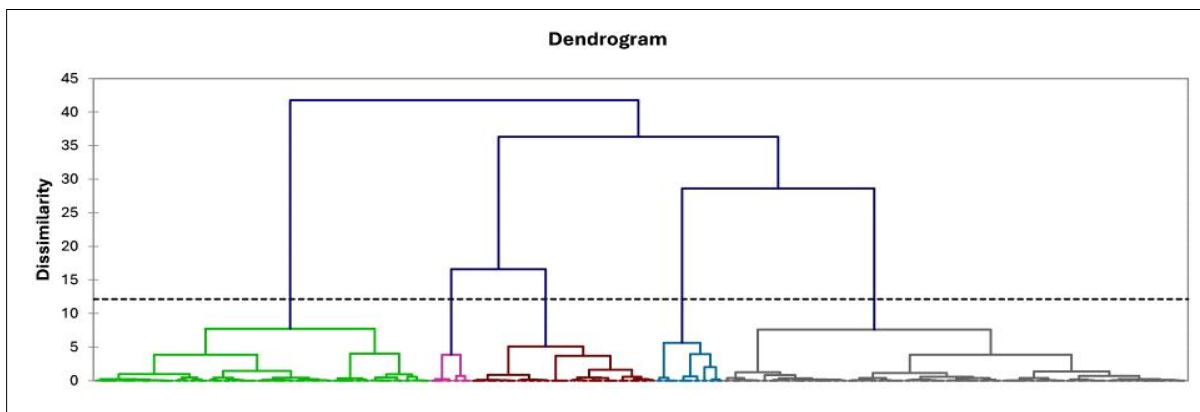


Fig 3: Dendrogram obtained to characterize the small ruminant production systems in Northern Jordan.

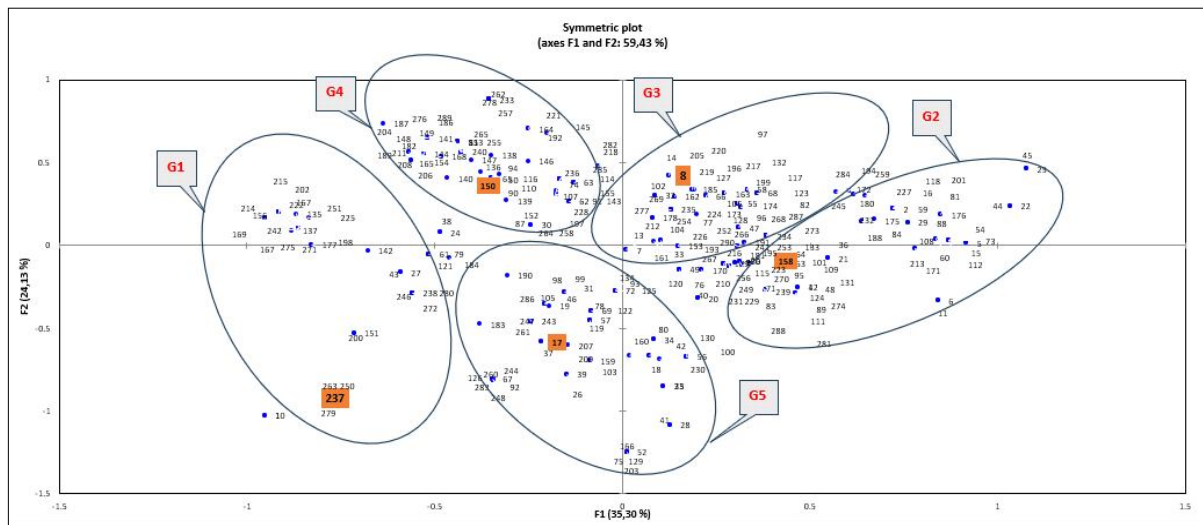


Fig 4: Symmetric plot showing the grouping of 290 small ruminant holders into five clusters.

The average age was 48, with 78% middle-aged. 55% had a high school education or lower. 56% had 5-10 years of experience, while 44% had 10-30 years. 56% relied solely on small ruminant production, while 44% also grew crops. 67% did not hire workers and relied on family labor. All relied on outside income, with an average holding of 164 small ruminants. Most had small flocks and raised both sheep and goats. On average, 44% raised small ruminants for cash sale, 44% for milk production and 11% for both. 56% did not provide supplementary feed like rain-fed residue and 67% purchase new animals to sustain their stock.

The fourth group (G4) is characterized by extensive sheep farming, with farmers primarily raising sheep in large flock sizes of over 500 heads. These farmers rely on natural resources rather than supplemental feed and focus on cash sales. The majority of G4 farmers were located in Mafraq. Most farmers filled into the Middle-aged category (49%). 65% of farmers had limited education, with an average of 35 years of experience in sheep farming. While only a small percentage of farmers also cultivated crops, the majority rely on family labor for their operations. Small ruminant production served as the main source of income for 91% of farmers, with sheep being the primary asset. The average flock size was 826 heads, with approximately half having large flocks. Most farmers (87%) focus on cash sales rather than milk production. The majority utilizing an extensive production system. Limited provision (less 8%) of rain-fed residue or tree trimming was seen, with sustainability remaining a common theme in the management of these flocks.

The last group (G5) consists of experienced small ruminant farmers with medium flock size and diversified sources of income, representing 17% of the total. These farmers typically had 10-30 years of experience and relied on small ruminants as their main source of income. They had medium-sized flocks, and also engaged in crop production. The majority of these farmers (65%) were

located in the Mediterranean region, particularly in Jerash and Irbid governorates. The majority of farmers (55%) falling into the middle age group. In terms of literacy, 12% have a bachelor's degree, 4% have higher education, 31% have less than a Tawjhi, 29% can read and write and 25% have a Tawjhi. These farmers have an average of 35 years of experience. The majority of them cultivate crops and raise small ruminants, with over 71% hiring paid workers. Small ruminants are the main source of cash for 74% of the farmers and all farmers rely on their own animals. The average flock size is 290 head, with 76% of farmers having a medium-sized flock. These farmers use a semi-extensive production system, feed their animals tree trimmings, shrubs and rain-fed residues.

The examination of small ruminant production systems in the Northern Jordan did not reveal uniformity in terms of structural, cultural, technical and economic aspects through the use of descriptive statistics. The typological analysis identified five distinct groups with unique management strategies, highlighting the importance of tailoring interventions to specific group characteristics. Multivariate analysis proved effective in characterizing farming systems, although results may be influenced by data nature (Arandas *et al.*, 2020). Categorizing farms with similar characteristics can streamline system characterization and deepen understanding of unique system characteristics (Silveira, 2021).

The first group (G1) identified in our analysis focuses on the management of labor within small ruminant production systems, with variables such as family members, paid-workers, part-time workers and the source of small ruminants playing a crucial role in system efficiency and productivity. Hiring paid part-time workers indicates a farmer's willingness to supplement their labor force, while the source of small ruminants may impact the decision to hire additional labor, especially in larger flocks or herds requiring more assistance. Small ruminant farmers with

higher levels of education may have a greater understanding of animal husbandry practices and access to advanced farming techniques, potentially leading to outside interests and job opportunities that could affect their ability to care for their animals. Collaboration with skilled part-time workers can help address the challenges of balancing outside commitments with the demands of livestock farming, while understanding the dynamics of family labor and the increasing reliance on hired labor can inform strategies for sustainable small ruminant production systems (Hostiou *et al.*, 2020). Research by Dupraz and Latruffe (2015) suggests that hired labor complements rather than substitutes family labor in management tasks and technical operations, emphasizing the importance of effective labor management for the sustainability and viability of small ruminant production systems.

The second group (G2) displays a strategic approach to managing the economics and sustainability of small ruminant production systems. By making well-informed decisions regarding animal replacement, these farmers aim to ensure the long-term viability and profitability of their operations. The preference for replacing animals from their own stock within this group highlights a focus on sustainability and self-sufficiency, potentially reducing the need for external inputs and associated costs. However, the choice between purchasing new animals or utilizing existing stock for replacement depends on various factors such as financial implications, confidence in the productivity of purchased animals, disease-free status, inbreeding concerns, access to breeding stock and individual farmer objectives for their production system (Eteqadi *et al.*, 2014; Tabbaa *et al.*, 2018). These findings align with previous studies that show the influence of factors like property and flock types on replacement management, emphasizing the importance of genetic management within the herd to maintain a healthy and sustainable small ruminant population (Tesema and Kebede, 2022 ; Awad *et al.*, 2023a ; Awad *et al.*, 2023b).

The variables within the third group (G3) are interconnected around market-driven production. Farmers with low and moderate experience tend to have a better understanding of market demands, enabling them to make informed decisions when purchasing small ruminants. This aligns with previous research by Yusuf *et al.* (2018) showing the benefits of experience in managing sheep and goats. The adoption of intensive production systems and the focus on meeting market demands suggest a business-oriented approach to small ruminant farming by G3. Furthermore, the adoption of an intensive production system suggests a keen focus on maximizing productivity and efficiently meeting market demands. This perspective is supported by studies conducted by Tiezzi *et al.* (2019).

Variables in Group 4 (G4) are interconnected in characterizing a large-scale sheep production operation that aims to maximize profitability while minimizing costs. The type of work, flock size and flock structure indicate the

scale and goals of the operation. The main purpose of raising small ruminants and the chosen production system reveal the economic objectives and strategies being used. The feed supplement variables, particularly the lack of tree trimming or shrubbery, highlight the reliance on natural resources and minimal use of supplemental feed in this farming system. These features align with previous studies confirming that extensive farming systems involve animals grazing on natural pasture with little supplementary feeding, categorized as low-input farming systems (Khaskheli *et al.*, 2020; Karthik *et al.*, 2021). Furthermore, Qi *et al.* (2023) have observed that extensive farming systems have lower intensity but higher sustainability compared to other farming methods.

Group 5 includes farmers with 10-30 years of experience, who rely on small ruminants for income, have medium-sized flocks, engage in crop production and use a semi-extensive production system. Sustainability and diversified income sources are important to this group (Kasapidou *et al.*, 2021). This system is gaining popularity due to its profitability and sustainability. It provides a balance between cost-effectiveness and production potential, making it a viable option for farmers looking to lower feeding costs while maintaining efficiency (Lawal *et al.*, 2020).

CONCLUSION

This study in the Northern Jordan has provided valuable insights into the diverse small ruminant production systems operating in the area. Through the use of multivariate analyses and typological analysis, we were able to categorize farmers into five distinct groups based on their management strategies, production practices and socio-economic characteristics. These groups, ranging from labor management-oriented to market-driven and extensive sheep farming-focused, reflect the complexity and variability within small ruminant production systems. By understanding the unique characteristics and priorities of each group, tailored interventions and support mechanisms can be implemented to enhance the sustainability, profitability and overall efficiency of small ruminant farming in the region. The findings from this study can serve as a foundation for future research, policy-making and extension services aimed at improving the resilience and productivity of small ruminant production systems in Northern Jordan.

Conflict of interest

All authors declare that they have no conflicts of interest.

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