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Ovine Husbandry In The Algerian Semi-Arid Zone: Contribution To The Resilience Of Agricultural Holdings To Climate Change And Economic Pressures

Manallah Imene[1,2,3*], **Abbas Khaled**[4]
[1]Department of Agronomic Sciences, University of Setif, 19000, Algeria
[2]Laboratory of Health and Environment, Faculty SNV-TU, University Bachir Il Ibrahimi of Bordj Bou Arreridj, Algeria.
[3]Teacher Education College of Setif, Algeria
[4]Algerian National Agronomic Institute, Algeria
Corresponding author*i.manallah@ens-setif.dz
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Abstract
This study sheds light on the significance of ovine husbandry in the resilience and sustainability of agricultural holdings. It seeks to develop a typology of holdings using qualitative variables and to examine the role of ovine husbandry in their resilience and sustainability. Qualitative data were collected in 2023 from 116 holdings engaged in ovine husbandry. A Principal Component Analysis for Categorical Variables (CATPCA), succeeded by a hierarchical cluster analysis, was employed to develop a typology. Four groups of holdings were delineated: (1) rainfed cereal agriculture and traditional ovine pastoralism, (2) rainfed and irrigated cereal agriculture with a focus on small ruminants, (3) rainfed cereal agriculture and diversified livestock, and (4) diversified mixed crop-livestock systems with irrigation access. Ovine husbandry is essential to the resilience of these holdings due to its robustness, capacity to use scarce forage resources, and function as a liquid capital reserve during crises. Irrigation access, production diversity, and a high proportion of ewes are key adaptation strategies, while only rainfed systems are susceptible to climate variability. Recommendations encompass the promotion of animal and crop diversification, enhancement of irrigation access, selection of cereal types and ovine breeds suited to the semi-arid climate, and strengthening of sustainable natural resource management methods. An integrated crop-livestock strategy would enhance food security and the sustainability of agro pastoral systems in semi-arid regions.
Keywords: *livestock, pastoralism,rainfed cereal, sustainability*

INTRODUCTION

The steppic region, with more than 30 million hectares, is predominantly allocated for the cultivation of small ruminants, highlighting the significance of these animals in local economies (Abbas, 2012). In the semi-arid high plains of Eastern Algeria, more than 80% of agricultural holdings engage in ovine husbandry, establishing ovines as the predominant livestock species, surpassing caprines and bovines (Benyoucef *et al.*, 2000).

The Sétif region, situated in the high plains, is a main area for livestock production in the country, distinguished by a significant concentration of ovine holdings. Yet, ovine farmers encounter numerous challenges (Kanoun, 2019). High temperatures and humidity represent a major challenge, undermining herd management and adversely affecting ovine health and welfare, resulting in diminished productivity and considerable economic losses (Yerrou,2021).

Concurrently, the simultaneous decrease in precipitation and seasonal inconsistency has led to a diminishment of accessible forage resources. Economic constraints exacerbate the situation: due to the challenges in obtaining subsidized concentrates, farmers must seek optimal alternatives to maintain their flocks (Slimani,2021).

All research and development methodologies must consider these elements to comprehend, target, and incorporate models and recommendations for production enhancement associated with a commitment to sustaining the viability of holdings (Benyoucef *et al.*, 1999).Farmers must exercise heightened awareness to recognize threats and mitigate their effects, use strategic management to foresee these circumstances and make informed decisions (Benniou, 2009).

The analysis of ovine holding typologies serves as a significant tool for comprehending local dynamics and pinpointing avenues for enhancement.

Typology facilitates the classification of holdings based on their structural, technical, and socio-economic characteristics, enhancing comprehension of their diversity (Perrot et Landais,1993). This approach enhances understanding of the strategies employed by farmers by elucidating the aspects that affect their performance and adaptability to changing circumstances. This research seeks to develop a typology of holdings grounded in qualitative variables and to examine the significance of ovine husbandry in the resilience and sustainability of these agricultural holdings.

MATERIAL AND METHODS

Research Area

The research area, Setif, is located in Algeria's semi-arid region. It is situated at an average altitude of 1,080 m and is defined by a semi-arid continental climate featuring three bioclimatic zones.The average annual precipitation for the entire province is roughly 400 mm (Figure 1).During summer, temperature routinely surpasses 40°C, while in winter, it frequently falls below zero.Average annual precipitation is approximately 400 mm for the entire wilaya (Figure 1).In summer, the temperature frequently exceeds 40 °C, whereas in winter, it often drops below zero.

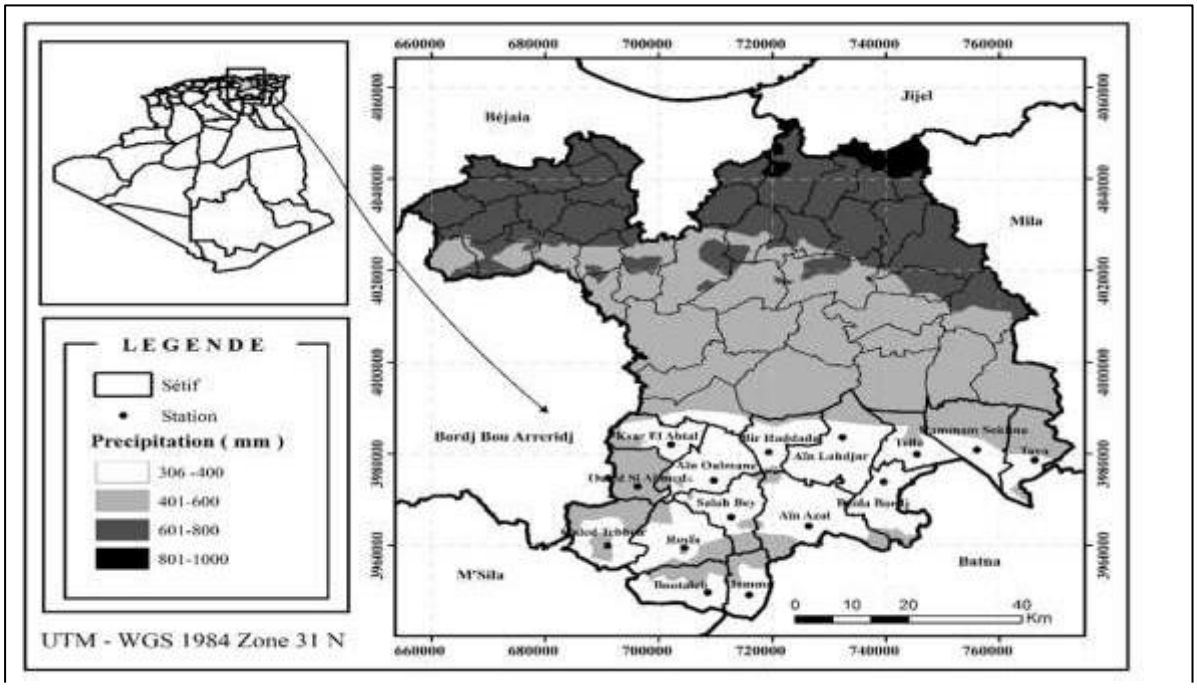

Figure1.Location of the research area

Data Collection

Data were collected in 2023 using structured field surveys administered to agropastoralists in the lower Setif region. The database contains 116 entries related to ovine husbandry.

Data Analysis

Seven qualitative variables were chosen to characterize the ovine holdings, presented as categories (Table 1).

A dimensionality reduction approach using Categorical Principal Components Analysis (CATPCA), succeeded by Hierarchical Cluster Analysis (HCA), was employed on a sample of 116 ovine holdings. The typology was conducted using IBM SPSS 27 software.

Table 1. List of modalities for the variables used in the analysis

Variable Code	Variable Name	Categories	Description
wa_rs	Water resources	1 2	No Yes
crp_prd	Crop production	1 2 3 4	Cereals Cereals and arboriculture Cereals and market

			gardening Cereals, arboriculture, and market gardening
crl-frm	Cereal farming	1 2 3	Rainfed Irrigated Mixed
crl_sp	Cultivated cereal species	1 2 3	Barley Barley and wheat Wheat
prc_ws	Percentage of ewes	1 2	<50% >50%
bv_sz	Bovine herd size	1 2 3	Small Medium Large
lv_sp	Raised livestock species	1 2 3 4	Ovine Ovine caprine Ovine bovine Ovine, caprine, bovine

RESULTS AND DISCUSSION

Main Characteristics of the Surveyed Holdings: The characteristics of the agricultural holdings in our samples are encapsulated in Table 2.

A predominant 54.3% of farmers fall between the 35-55 age demographic, signifying the most engaged group in agricultural activities. This suggests that ovine husbandry in this area is predominantly overseen by seasoned, middle-aged farmers, possibly integrating traditional knowledge with physical capabilities.

Farmers aged over 55 constitute 33.6%, indicating the persistent participation of the elderly in this sector, attributed to inheritance, familial traditions, and the absence of alternative income sources in rural regions.

Farmers aged 25 to 35 constitute 12.1%, signifying minimal participation. This disinterest may underscore the challenges faced in engaging younger generations in ovine husbandry. Their disengagement may stem from economic difficulties and urban migration.

Fertas (2024) indicated that the urbanization rate of the province of Setif was 29.3% in 1987 and increased to 47.9% in 2018. The workforce is primarily family-based (54.3%), whilst

21.6% depend on salaried employment and 24.1% use a combination of both. The dependence on familial labor signifies the independence of agricultural holdings in this area. The incorporation of salaried labor signifies a degree of agricultural commercialization.

A predominant proportion of farmers are both owners and renters (83.6%), whereas merely 14.7% alone possess land and 1.7% rely totally on leased land. Water resources are evenly allocated, with 50% of farmers possessing access and 50% lacking it. This aligns with Semara's (2021) findings in the southern region, where deep well drilling serves as the primary water source for agriculture and livestock, facilitating 54.3% of farmers in fulfilling their requirements.

Concerning crops, 50.9% of farmers engage in rainfed cereal farming, 4.3% rely on irrigation, and 44.8% employ a mixed method.

The prevalence of rainfed grain agriculture underscores the region's reliance on unpredictable precipitation, rendering cereal production exceedingly susceptible to drought conditions. The significant prevalence of mixed irrigation practices reflects endeavors to enhance productivity via resource diversification.

The mixed system (44.8%) signifies that certain farmers implement a risk mitigation technique by integrating rainfed and irrigated crops. Barley is the predominant cereal cultivated (50.9%), followed by combinations of barley and wheat (46.6%), while just wheat cultivation accounts for only 2.6%. The prevalence of barley aligns with other studies indicating that it is the primary feed for sheep in Algeria (Benmahamed,2004); it is well-suited to semi-arid regions and functions as the principal feed source for livestock (Rahal-Bouziane,2015).

A high proportion (88.8%) of farmers do not engage in market gardening, whereas 11.2% incorporate it into their practices. The minimal integration of arboriculture (19.8%) and market gardening (11%) indicates restricted diversification, resulting in increased reliance on livestock and cereals by farmers. 72.4% of farmers grow green barley for forage, 22.4% cultivate oats, and 3.4% employ a mixture of green barley and oats. Merely 1.7% of farmers do not engage in forage crop cultivation, signifying that nearly all farmers incorporate some degree of forage production to sustain their livestock. The prevalence of green barley over oats corresponds with regional trends, since barley is favored for its superior adaptability and biomass yield in arid circumstances. 31% of farmers do not engage in fallowing, whereas 69% use fallow land, with 36% employing owned property and 80% using leased land for this purpose. The significant incidence of leased fallow land indicates that land availability is a limiting constraint, necessitating farmers to lease supplementary land for grazing.

Fallowing is a crucial strategy for preserving soil fertility in semi-arid areas. A substantial percentage of ovine holdings (77.6%) maintain herds comprising fewer than 200 head, while 39.7% oversee herds of fewer than 100 sheep. This signifies a prevalence of small- to medium-scale ovine husbandry.

A comparable trend is evident in the population of ewes: 67.7% of farmers possess less than 100 breeding ewes. The comparatively small quantity of ewes per holding indicates a mostly broad production system. 64.6% of properties also engage in caprine husbandry. Sahraoui *et al.* (2016) indicated that 61% of caprine husbandry is frequently linked to ovine husbandry (Saidani,2019). This highlights the supplementary function of goats in various agricultural systems, since they may consume forage areas not completely exploited by sheep, thus diversifying farmers' income and fulfilling their family's milk needs. 44% of properties do not engage in bovine husbandry.

Nonetheless, 26.7% of farmers oversee herds including 5 to 20 cows, while merely 5.2% surpass 20 head. A great proportion of farmers (37.9%) engage in mixed livestock production, integrating ovine, caprine, and bovine species. This multifaceted strategy guarantees robustness against environmental unpredictabilities and economic fluctuations by maximizing the usage of land and feed resources.

The existence of small specialized groups in ovine-caprine husbandry (26.7%) or ovine-bovine husbandry (19%) indicates divergent farm management practices.

Table 2. Overall Characteristics of the Surveyed Holdings

Characteristics		**(n)**	%
Farmer's age	25-35 years	14	12,1
	35-55 years	63	54,3
	>55 years	39	33,6
Education level	Illiterate	34	29,3
	Primary	25	21,6
	Lower secondary	43	37,1
	Secondary	12	10,3
	University	2	1,7
Labor	Family	63	54,3
	Salaried	25	21,6
	Family and salaried	28	24,1
Land tenure	Owner	17	14,7
	Tenant	02	1,7
	Owner and tenant	97	83,6
Water resources	Without water resources	58	50
	With water resources	58	50
Cereal farming	Rainfed	59	50,9
	Irrigated	5	4,3
	Mixed	52	44,8
Cultivated cereal species	Barley	59	50,9

	Barley and wheat	54	46,6
	Wheat	03	2,6
Market gardening	Without market gardening	103	88,8
	Market gardening	13	11,2
Arboriculture	Withoutarboriculture	93	80,2
	Arboriculture	23	19,8
Cultivated forage	Withoutcultivated forage	2	1,7
	Green barley	84	72,4
	Oats	26	22,4
	Green barley and oats	4	3,4
Fallow	Fallow in its own right	36	31
	Leased fallow	80	69
Ovine herd size	<100	46	39,7
	100-200	44	37,9
	>200	26	22,4
Number of ewes	Less than 50	44	37.9
	From 50 to 100	45	38,8
	More than 100	27	23,3
Number of goats	Zero goat	41	35,3
	Less than 5	36	31
	From 5 to 20	33	28,4
	More than 20	6	5,2
Number of cows	Zero cow	51	44
	Less than 5	28	24,1
	From 5 to 20	31	26,7
	More than 20	6	5,2
Association with other ruminants	Ovine	19	16,4
	Ovine and caprine	31	26,7
	Ovine and bovine	22	19
	Ovine, caprine and bovine	44	37,9

Results of the CATPCA Analysis

The initial two factorial axes represent 62.57% of the overall variation. The F1 axis accounts for 36.59% of the variance, while the F2 axis accounts for 25.98% (Table 3).

Table 3. Contribution of Variables to Axes F1 and F2

Variable	**Dimension**	
	1	2
bv_sz	.601	.745
crl-frm	.820	-.474
crp_prd	.477	-.394
prc_ws	-.303	.125
lv_sp	.549	.776
wa_rs	.823	-.455
esp_cul	.480	.240
% variance	36,59%	25,98%
% **Cumulative variance**	62,57%	

Typology of Agricultural Holdings with Ovine Husbandry: The typology made it possible to distinguish four groups of farms:

Rainfed cereal farming and small ruminant husbandry:

Group 1 exemplifies a conventional pastoral framework modified for semi-arid areas, distinguished by rainfed grain agriculture and substantial, robust small ruminant husbandry (ovines 36.7% and caprines 63.3%). Ovine husbandry constitutes the principal activity within this group. A significant percentage of ewes (76.7%) is present, suggesting that emphasis is placed on herd expansion and reproduction over the diversification of livestock species.

Rainfed and irrigated cereal farming with a specialization in small ruminants:

Group 2, is characterized by a mix of rainfed and irrigated cereal crops, along with specialized small ruminant husbandry, where ovine flocks are primarily constituted of ewes (75%). This composition demonstrates an enhanced reproductive strategy.

Rainfed cereal farming and diversified livestock:

Group 3 exemplifies a diversified agricultural system in a semi-arid zone, integrating rainfed cereal crops with livestock husbandry that includes either ovines and caprines (22.6%) or a mixed herd with bovines as well (77.4%). This group is highly reliant on precipitation, with 90.3% of its members lacking access to water resources.

Diversified mixed crop-livestock system:

Group 4 exemplifies a varied agropastoral system. This system integrates cereal polyculture, arboriculture, and market gardening with diversified animal husbandry, incorporating either ovines and caprines (44.4%) or ovines and bovines (55.6%). Almost universal access of water resources (100%) enables these farmers to engage in irrigation practices.

The Central Role of Ovine Husbandry in the Resilience of Holdings in Semi-Arid Zones

Traditional Ovine Pastoralism: Ecological Resilience and Reproduction

In Group 1, emblematic of conventional pastoralism, ovine husbandry is fundamental to the sustainability of the holdings. The high percentage of ewes (67.7%) indicates a focus on reproduction and herd growth, crucial for the viability of pastoral systems amid considerable climate uncertainty. The research conducted by Akejo (2017) and El Ayadi *et al.* (2024) substantiate that the resilience of ovines and their capacity to use suboptimal plant resources are significant advantages in semi-arid regions.

The exclusion of bovines is a decision that enables farmers to circumvent the substantial water usage linked to this form of husbandry, so rendering small ruminants a more sustainable alternative in regions experiencing water scarcity and severe environmental challenges (Oluwakamisi,2019).Nonetheless, reliance on rainfed cereal farming renders these systems susceptible to significant interannual fluctuation, thus enhancing the role of ovines as a safety for rural households. The lack of irrigation resources in this group confines farmers to rainfed cereal crops, such as barley and wheat, which are drought-resistant but generate lower and less reliable yields compared to irrigated crops. The yields of rainfed cereals are significantly influenced by precipitation; Benmmehaia *et al.* (2020) demonstrate that average yearly precipitation is a crucial factor in yield variability.

Ovine Reproductive Specialization and Securing of Incomes

Group 2, defined by rainfed and irrigated cereal farming coupled with specialized small ruminant husbandry, prioritizes a substantial proportion of ewes (75%), indicating a sophisticated reproductive strategy. The feminization of the herd enhances lamb production, guaranteeing a consistent income stream and a swift recovery capability during droughts or crises. These techniques enhance the system's sustainability and provide successful adaptation to constrained resources, aligning with the findings of Benyoucef et al.(1999) and Al Barakeh (2024). This model is especially pertinent in resource-limited environments, because ongoing reproduction serves as a mechanism for resilience.The lack of bovines is attributed to the superior adaptability of ovines and caprines to arid areas, where their resilience and low water needs are significant assets for the resilience of the holdings. They demonstrate enhanced abilities for survival, production, and reproduction in extreme temperatures, rendering them more tolerant to scarce forage resources (Joy,2020).

Ovines as a Balancing Factor in Vulnerable Rainfed Systems

Group 3, which depends on rainfed cereal farming and varied livestock, underscores the susceptibility of holdings that rely solely on precipitation. In this context, ovine husbandry serves as a safeguard against the variability of cereal yields, offering crucial economic and nutritional flexibility. Abbas *et al.* (2002) proved that ovines, due to their resilience and capacity to use limited plant resources, serve as an economic

stabilizer in semi-arid cereal holdings. The inclusion of ovines enables the adaptation of herd management based on resource availability, therefore mitigating losses in years of low rainfall and enhancing income stability.

Ovine Husbandry: A Pillar of Diversification and Stability

Ovine husbandry is pivotal to the resilience of agricultural holdings in Algeria's semi-arid regions, especially within varied agropastoral systems.

In Group 4, the integration of polyculture with mixed livestock husbandry (ovine, caprine, and bovine) and extensive irrigation access facilitates the procurement of animal feed, stabilizes yields, and diminishes reliance on external inputs. This integration enhances forage self-sufficiency, crucial for mitigating impacts from climate variability and market fluctuations, thereby corroborating the findings of Dahmani *et al.* (2025) regarding the advantages of irrigated systems for food security and the resilience of agricultural holdings.

In this sense, ovines serve not just as a source of meat but also as a "capital reserve" that can be activated during crises. The incorporation of ovine husbandry into this system corresponds with the findings of Larbi *et al.* (2023) about crop-livestock integration, wherein ovine husbandry serves as a supplementary approach to enhance the security and stability of holdings. This diversification enhances resilience to market and climate variability, as the various crops and livestock offer alternate revenue streams (Islam,2024).This finding alignswith conclusions indicating that diversity typically mitigates income-related risk (Fabri,2024).

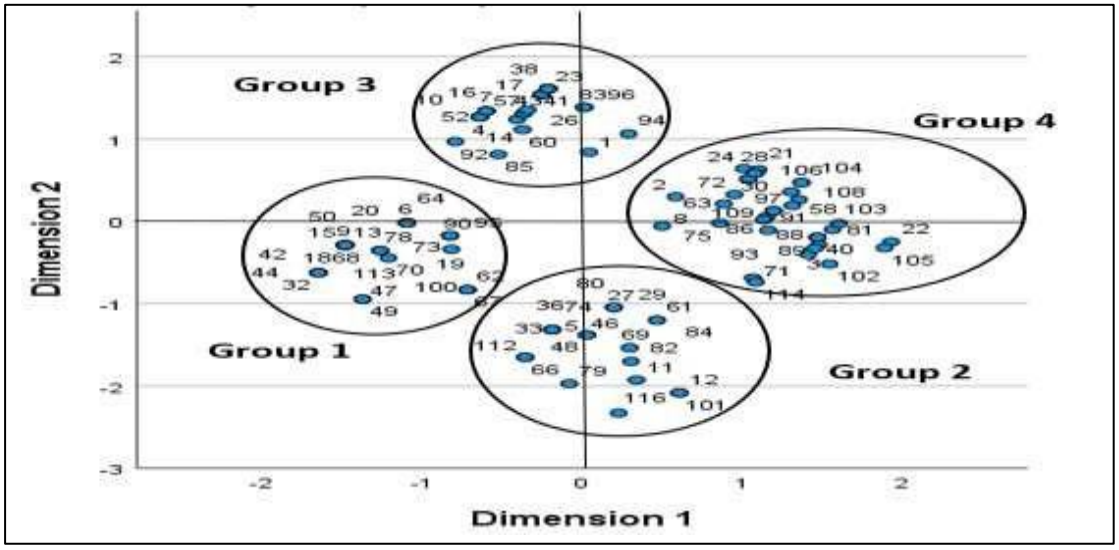

Figure2.Projection of types of Agricultural holdings on principal plan

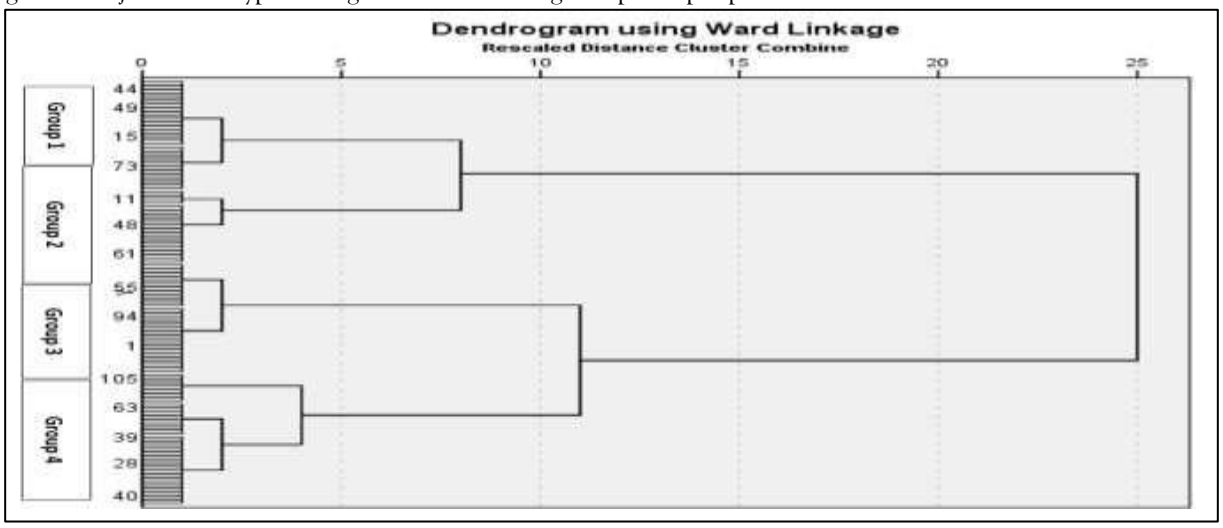

Figure 3. Dendrogram of the hierarchical classification of holdings

Table 4. Characteristics of the types of holdings

Characteristics	**Type1 (n=30)**	**Type 2 (n=20)**	**Type 3 (n=30)**	**Type 4 (n=36)**
Water resources	0%	100%	6.7%	100%
Crop production				
Cereal farming	80%	70%	96.7%	50%
Cereal farming and other crops	20%	30%	3.3%	50%
Cereal farming type				
Rainfed	100%	0%	96.7%	0%
Irrigated	0%	0%	3.3%	11.1%
Mixed	0%	100%	0%	88.9%
Cultivated species				
Barley	56.7%	55%	40%	13.9%
Barley and wheat	36.7%	45%	50%	86.1%
Wheat	6.7%	0%	10%	0%
Livestock				
Ovine	36.7%	40%	0%	0%
Ovine and caprine	63.3%	60%	0%	0%
Ovine and bovine	0%	0%	20%	44.4%
Ovine, caprine, and bovine	0%	0%	80%	55.6%
Percentage of ewes				
Less than 50%	23.3%	25%	16.7%	38.9%
More than 50%	76.7%	75%	83.3%	61.1%
Bovine herd				
Absence of bovines	100%	100%	0%	0%
Presence of bovines	0%	0%	100%	100%

CONCLUSION

The main objective was to delineate several ovine husbandry systems, analyze the degree of ovine integration, and evaluate their contribution to the sustainability and resilience of the holdings amid environmental and economic uncertainty.

Diversity of Systems: Four distinct groups of holdings were identified, spanning from conventional pastoral systems focused on small ruminants to diversified mixed crop-livestock systems.

Central Role of Ovines: Ovine husbandry has become a cornerstone of resilience due to its adaptability, robustness, and capacity to use inferior plant resources effectively. It serves as a mobilizable capital reserve during crises and stabilizes household earnings.

Adaptation Strategies: Irrigation access, diversification of productivity, and a substantial proportion of ewes are critical factors for adaptation and sustainability.

Persistent Vulnerability:

Systems solely reliant on rainfed cereal farming are susceptible to climate fluctuation, highlighting the necessity for diversification and integration.

The sustainability of these systems relies on the application of natural resource management strategies, access to irrigation infrastructure, and the creation of climate-resilient cereal varieties (especially those resistant to drought, heat, and diseases) alongside ovine breeds more suited to semi-arid environments. A comprehensive strategy that merges agricultural diversification with water resource optimization may enhance the resilience and sustainability of agropastoral holdings in the region. The cultivation of plant types is crucial for sustaining food production under climate change. These approaches enhance

agricultural productivity and reduce environmental consequences, therefore providing sustained food security amid changing climatic conditions. The research improves comprehension of local crop-livestock integration dynamics in semi-arid regions. This highlights the special role of ovines in the resilience of agricultural systems and suggests an operational typology of ovine holdings, beneficial for the formulation of targeted strategies. The findings illustrate the importance of advocating for diversified and integrated systems to enhance food security and sustainability.

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Conflict of interest: Regarding the publication of this manuscript, the authors declare that there are no conflicts of interest.

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