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Diversify or specialize? Household livestock strategies along an oasis urbanization gradient in southeastern Algeria

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Abstract

Family livestock farming is an important component of livelihoods in many arid regions, where it contributes to food security and the diversification of household income. In the Saharan region of Ouargla (Algeria), socio-economic changes and increasing urbanization are gradually altering agricultural production systems. However, family livestock farming remains a common activity among households, including in urban areas such as the Ksar Ouargla. This study analyses the diversification of family livestock farming systems and their contribution to household income along a rural–urban gradient. Data were collected from 240 livestock-rearing households spread across four areas: Sidi Khouiled, Ngoussa, Rouissat and the Ksar Ouargla. Livestock diversification was measured using Simpson's index, and economic determinants were analyzed using linear regression models. The results show that the average livestock diversification index is 0.46, with higher levels in rural areas. Herd size has a significant positive effect on livestock income ($p < 0.001$), while livestock diversification has a significant negative effect ($p < 0.01$). Family livestock farming also persists in urban areas, despite spatial constraints. These results highlight the existence of a trade-off between diversification for risk management and specialization for economic performance in family livestock systems in arid regions. The present work thus contributes to a better understanding of the role of family livestock farming in the livelihood strategies of households in Saharan regions and highlights the dynamics of transformation in livestock systems along the rural–urban gradient.

1- Introduction

Livestock plays an essential role in the livelihoods of rural and peri-urban populations in many regions of the world, particularly in arid and semi-arid areas (FAO, 2018; Habib et *al*., 2023). In these environments characterized by limited resources and high climate variability, livestock activities often constitute an important source of income, contributing to household food security and economic resilience (Dubost, 2002; Herrero et *al.*, 2016; Daramola et *al*., 2021; Bekee et Valdivia, 2023). Livestock systems thus represent a central element of livelihood strategies in many developing countries (Loison, 2015; Ellis, 2000; Adams et *al*., 2025).

In many agricultural contexts, livestock is practiced in the form of family farming, characterized by the use of family labor and the valorization of available local resources (McDermott et *al.*, 2010; FAO, 2011). These systems fulfill several economic and social functions, notably the production of animal-based food products (milk, meat, and eggs), the generation of supplementary income, and the formation of a form of savings for households (McDermott et *al.*, 2010; Adams et *al*., 2025).

In arid environments, farming households frequently adopt livestock diversification strategies combining several animal species to reduce risks related to climate fluctuations, animal diseases, or market variations (Ellis, 1998; Ellis, 2000; Barrett et *al.*, 2001). This diversification constitutes an important adaptation mechanism that strengthens the stability of production systems in the face of economic and environmental uncertainties (Loison, 2015; Thornton et *al.*, 2010).

In North Africa, small ruminant livestock systems hold a central place in rural economies and household food security (Laouadi et *al.*, 2018). In the arid zones of the Maghreb, sheep and goat farming often constitutes an important source of income for agricultural holdings (Chentouf, 2014). The goat, in particular, stands out for its hardiness and its ability to adapt to difficult environmental conditions, allowing it to utilize low-quality forage resources (Devendra, 2013; Laouadi et *al*., 2018; Mashamaite et Tada, 2025). It thus contributes significantly to the food security of rural households and is often described as "the poor man's cow" (Peacock, 2005; Meza-Herrera et *al*., 2024; Kichamu et *al*., 2024).

In Algeria, particularly in the Saharan regions, territories have undergone transformations in recent decades related to urbanization and the diversification of economic activities (Côte, 2006; Bisson, 2010). Despite these changes, family farming remains a widely practiced activity.

However, scientific knowledge remains limited regarding the factors that influence the diversification of family farming systems and their contribution to household income in Saharan contexts. In this context, this study aims to analyze the diversification of family farming systems and their contribution to household income in the Ouargla region along a rural-urban gradient. Three hypotheses are examined: (i) rural systems exhibit higher livestock diversification than urban systems; (ii) herd size influences household livestock income; and (iii) diversification constitutes a risk adaptation strategy in arid environments.

2- Materials and methods

2.1. Study areas

The study was conducted in the Ouargla region, located in the Algerian Sahara in the south-east of the country. This region is characterized by an arid to hyper-arid climate, with annual rainfall generally below 100 mm and summer temperatures that can exceed 45°C. These challenging environmental conditions strongly influence agricultural production systems and livestock farming practices.

The region is also undergoing significant socio-economic changes, linked in particular to urbanization, infrastructure development and the diversification of economic activities. Despite these developments, family-based livestock farming remains widely practiced and constitutes an important complementary activity in households' livelihood strategies.

In order to analyze livestock farming practices in different geographical contexts, the study was conducted in four areas representing a rural–urban gradient (Fig. 1):

- **Sidi Khouiled**: a rural area characterized by a strong presence of agricultural and livestock farming activities;
- **Ngoussa**: a rural area where livestock farming is also widespread;
- **Rouissat**: a peri-urban area characterized by the coexistence of agricultural and urban activities;

- **Ksar Ouargla**: an urban area where family livestock farming is mainly practiced within the domestic sphere.

This territorial gradient enables an analysis of variations in family livestock farming systems within contrasting socio-spatial contexts.

2.2. Types of livestock farming studied

The study focuses on family-based livestock farming systems, defined as farming activities carried out at the household level and relying mainly on family workforce. These systems contribute both to self-consumption and to income generation.

In the Ouargla region, livestock farming mainly involves goats, sheep and poultry, species well adapted to arid environmental conditions.

Livestock farming activities may be carried out:

- At the household's premises (courtyards, gardens or adjacent areas);
- On a farm, where households have a plot of land to house the animals.

Livestock management may be carried out by a man or a woman, depending on the household's internal organization.

2.3. Sampling and data collection

The data used in this study come from a field survey conducted in 2025 among 240 households engaged in family livestock farming.

A purposive sampling method was adopted to select households actually engaged in livestock farming. The sample was distributed evenly across the four study areas, with 60 households surveyed in each area.

Households were identified with the support of local agricultural services, livestock farmers' associations and local officials, to ensure the relevance of the sample.

Data were collected using a structured questionnaire administered directly to households. The information gathered relates in particular to:

- the socio-economic characteristics of households;
- the gender of the person responsible for livestock farming;
- the location of livestock farming (home or farm);
- the composition of the livestock herd;
- animal production (milk, eggs, sales of animals);
- income from livestock farming;

- the contribution of livestock farming to total household income.

The surveys were conducted with the voluntary consent of the households interviewed, and the data collected were used exclusively for scientific research purposes.

2.4. Variables studied and measurement of diversification

Several variables were constructed to analyze family livestock systems.

Structural variables include total herd size and herd composition (proportion of goats, sheep and poultry). Socio-organizational variables include geographical area, the gender of the person in charge of livestock farming and the location of the farming activity.

Economic variables include total household income, income from livestock farming and the share of livestock income in total income. Income variables are expressed in units corresponding to 100 US dollars per year (100 USD/year) to facilitate the interpretation of results.

The diversification of animal species reared by households was measured using Simpson's diversification index, defined as follows:

$$D = 1 - \sum_{i=1}^{n} P_i^2$$

Where: P_i represents the proportion of the species i in the total livestock population.

Index values range from 0 (low diversification) to 1 (high diversification).

2.5. Statistical and econometric analysis

The analyses were carried out using the R software (version 4.5.2).

Initially, descriptive statistics were calculated to characterize the livestock systems studied. Differences in diversification between zones and according to certain socio-organizational characteristics were tested using an analysis of variance (ANOVA), followed by Tukey's multiple comparisons where differences were significant.

Pearson's correlations were also calculated to examine the relationships between certain quantitative variables, notably herd size, diversification and livestock income.

To identify the factors influencing livestock income, linear regression models were estimated. To reduce the skewness of the income distribution and improve the statistical properties of the models, the income variables were transformed using the natural logarithm. Where income was zero, a constant was added prior to the logarithmic transformation.

The explanatory variables included in the models comprise, in particular, the livestock diversification index, herd size, geographical area, the gender of the person in charge of livestock farming, and the location of the livestock farming operation.

The validity of the models was verified using several diagnostic tests. The normality of the residuals was examined using graphical inspection and the Shapiro–Wilk test, heteroscedasticity was tested using the Breusch–Pagan test, and multicollinearity between explanatory variables was assessed using the variance inflation factor (VIF).

3- Results

3.1. General characteristics of family farming systems

The descriptive statistics for the main variables studied are presented in Table 1.

Table 1
Descriptive statistics of the main variables

Variable	Mean	Standard deviation	Minimum	Maximum
Total herd size	9.20	4.11	4	19
Number of goats	5.13	2.74	2	11
Number of sheep	1.55	1.88	0	6
Number of hens	2.52	2.60	0	8
Milk production (L/day)	3.72	2.02	0	8
Egg production (units/day)	1.88	2.01	0	5
Diversity index (Simpson)	0.46	0.17	0.00	0.66
Total income from livestock farming (×100 USD)	5.64	6.78	0.50	28.42
Total household income (×100 USD)	37.90	17.42	10.14	63.58
Share of income from livestock farming	0.35	0.31	0.02	1.00
Note: Income variables are expressed in units corresponding to USD 100 of annual income.				

The results show that the households surveyed own an average of 9.2 animals, with values ranging from 4 to 19 animals. The livestock population consists mainly of goats, supplemented by sheep and poultry. This livestock structure reflects the adaptation of livestock systems to the arid conditions of the region.

The average livestock diversification index, measured using Simpson's index, is 0.46, indicating a moderate level of diversification in family livestock systems.

Income from livestock farming varies significantly between households. The figures presented in the table correspond to income units equivalent to 100 US dollars. On average, livestock income accounts for around 30–35% of total household income, highlighting the economic importance of this activity in local livelihood strategies.

3.2. Organization of family livestock farming according to areas

The survey results show that the practices of family livestock farming vary according to geographical context (Fig. 2).

In the rural areas of Sidi Khouiled and Ngoussa, livestock farming is mainly practiced on agricultural holdings, providing households with relatively large areas for rearing several animal species.

In the semi-rural area of Rouissat, livestock farming practices appear more diverse, with the coexistence of domestic livestock rearing and livestock rearing on agricultural holdings.

In contrast, in the urban area of Ksar Ouargla, livestock farming is mainly carried out within domestic spaces, often in courtyards or gardens of limited size. Despite these spatial constraints, the results show that family livestock farming persists in this urban environment, demonstrating its enduring role in household economic strategies.

3.3. Diversification of livestock according to areas

The diversity of animal species reared by households was assessed using Simpson's diversity index (Fig. 3).

The results of the analysis of variance show that the study area significantly influences livestock diversification ($F = 3.85$; $p = 0.0127$).

Tukey's multiple comparisons indicate that diversification is significantly higher in the rural area of Ngoussa than in the urban area of Ksar Ouargla.

This trend suggests that households in rural areas more frequently combine several animal species (goats, sheep and poultry), whereas urban households tend to maintain more specialized livestock systems.

3.4. Relationship between herd size and diversification

The correlation analysis shows a positive relationship between herd size and the level of diversification in livestock systems (Fig. 4).

Pearson's correlation coefficient indicates that households with larger herds tend to rear a greater number of animal species.

This relationship suggests that the availability of greater livestock resources provides households with a greater capacity to diversify their livestock activities.

3.5. Contribution of livestock farming to household income

The economic contribution of family livestock farming to household income varies between farms (Fig. 5).

The results show that the average contribution of livestock farming is slightly higher in rural areas than in urban areas. However, statistical analyses indicate that these differences are not significant between the areas.

This suggests that, despite differences in the structure of livestock farming systems, the economic role of livestock farming remains relatively comparable across different geographical contexts.

3.6. Economic determinants of livestock income

The results of the linear regression model are presented in Table 2.

Table 2
Determinants of livestock income

Variables	Coefficient	Standard error	p-value
Intercept	0.242	0.276	0.383
Diversification	-1.306**	0.394	0.001
Total livestock	0.203***	0.021	< 0.001
Rural_Ngoussa	-0.085	0.163	0.605
Periurban_Rouissat	0.047	0.172	0.787
Urban_Ksar Ouargla	0.177	0.180	0.327
Male pilot	-0.612*	0.232	0.010
Breeding outside	0.393	0.266	0.143
Note: Rural_Sidi Khouiled is the reference category for the "Zone" variable			

Observations: 240 / R^2: 0.739 / Adjusted R^2: 0.714 / Residual standard error:

0.510 F-statistic: 29.16 ($p < 0.001$) Significance: *** $p < 0.001$ / ** $p < 0.01$ / $p < 0.05$

The results show that:

- Herd size has a positive and highly significant effect on livestock income ($p < 0.001$);
- Livestock diversification has a significant negative effect on livestock income ($p < 0.01$);

- Livestock farming systems run by women generate higher livestock incomes than those run by men.

These results suggest that more specialized livestock systems can generate higher incomes, while diversified systems appear to be more focused on food security and risk management.

Diagnostic tests were carried out to verify the validity of the regression model. The results indicate the absence of major issues of heteroscedasticity, multicollinearity and non-normality of the residuals.

4- Discussion

4.1. Persistence of family livestock farming under urban pressure

The results confirm that family livestock farming remains a resilient activity in the Ouargla region despite ongoing urbanization, including within the urban perimeter of Ksar Ouargla. This persistence should not be read merely as inertia; It reflects an active adaptation of households to spatial and economic constraints (Barrett et al., 2001; Bekee et Valdivia, 2023). Whereas rural households in Sidi Khouiled and Ngoussa rely on relatively open land to combine several species, urban households in Ksar Ouargla reorganize their livestock activity around confined domestic spaces and a narrower species base, mainly goats and poultry, without abandoning the activity altogether. This pattern is consistent with observations of urban and peri-urban livestock keeping in other African cities (FAO, 2012; Monau et al., 2015; Anim-Jnr et al., 2023), and situates Ouargla within a broader documented trend of livestock persistence under urban land pressure rather than a Saharan specific anomaly.

The prominence of goats across all four study areas, and particularly in Ksar Ouargla, is best understood as a structural adaptation rather than a simple preference. Goats combine low space requirements, tolerance of poor-quality forage, and daily milk production, which together make them the only livestock option compatible with courtyard-scale rearing (Toutain, 1979; Dubost, 2002; Devendra, 2013). This explains why urban specialization in this study converges almost systematically on goats rather than on sheep or poultry alone: goats are, in effect, the species best matched to the joint constraint of aridity and spatial confinement.

4.2. Structural explanation for the diversification-income relationship

The moderate diversification level observed in Ouargla (Simpson index = 0.46) and its negative association with livestock income depart, at first glance, from the more unambiguously positive role attributed to diversification in several other arid and semi-arid livestock systems (Chentouf, 2014; Chniter et al., 2024; Laroussi et al., 2026). This divergence is informative rather than contradictory, and stems from a key structural difference between Ouargla and many pastoral systems reported in the literature.

In extensive pastoral systems of the Sahel or the high plateaus, livestock is often the near-exclusive source of household income, and species diversification is one of the few available buffers against rainfall variability, disease and market shocks (Herrero et al., 2016; Adams et al., 2025). In Ouargla, by contrast, livestock operates within a diversified regional economy shaped by irrigated agriculture, public sector employment and, in urban areas, wage labor and services; livestock income represents on average only 30–35% of total household income, so diversification is not the household's primary risk management instrument, other sources already absorb part of the economic risk. Households with more land and larger herds, mainly in rural zones, can therefore diversity as a complementary, lower-stakes strategy, while land-constrained urban households specialize by necessity and draw resilience from their wider income portfolio rather than from herd composition. This distinction between livestock dependent pastoral economies and livestock embedded oasis economies explains why diversification appears economically costly here without contradicting its protective value elsewhere.

A complementary explanation concerns causality. Herd size and diversification are positively correlated ($r = 0.59$, $p < 0.001$), so diversification's negative coefficient should not be read as evidence that species mixing itself depresses income; It more plausibly reflects diversification's partial dependence on structural constraints. Urban households specialize because spacial confinement leaves them no alternative, and their forced reliance on goats, a productive, low input species, keeps income comparatively resilient despite small herds. Rural households diversify because they can, spreading labor and capital across species partly for food security and cultural reasons documented in the survey, not necessarily to maximize income. Income differences between zones are thus better explained by the joint effect of herd size, land access and species productivity than by diversification as an independent driver of welfare.

4.3. Policy implications of the diversification specialization trade-off

This distinction has direct implications for how the diversification specialization trade-off identified in Table 2 should be translated into policy, since it shows that diversification and specialization are not simply competing options that a single instrument could arbitrate, but strategies rooted in different structural positions.

For rural, land-secure households (Sidi Khouiled, Ngoussa), where diversification is a matter of choice rather than necessity, policy should not aim to increase diversification per se, since the data show this reduces measured livestock income. Instead, public support should help these households capture the productive efficiency associated with larger, better-managed herds, through breed improvement, veterinary coverage, milk collection and cold-chain infrastructure, so that specialization gains documented in the income model (herd size coefficient, $p < 0.001$) can be realized without eliminating the food-security buffer that a moderate degree of diversification still provides at the household level.

For land-constrained, largely urban households, where specialization in goat keeping is structurally imposed rather than freely chosen, the priority is different: since these households cannot diversify their

herd even if it were economically advantageous to do so, their resilience to shocks must be built through instruments external to the herd's composition, such as microinsurance products, veterinary subsidies targeted at small urban units, and regulated access to feed and health inputs, rather than through incentives to keep multiple species in an already constrained space.

In practical terms, this reframes the trade-off from a binary choice between 'promoting diversification' or 'promoting specialization' into a differentiated policy design that matches the instrument to the household's structural position along the rural-urban gradient, using land-based levers (fodder programs, veterinary services, breed improvement) where diversification is a strategic option, and non-land-based safety nets (insurance, subsidized inputs) where it is not.

4.4. Role of gender in family livestock systems

Livestock operations managed by women generate significantly higher incomes than those managed by men in this sample. This finding is consistent with evidence from several African contexts where women play a central role in managing small ruminants and poultry (Anim-Jnr et al., 2023) and where livestock activity strengthens women's economic autonomy within the household (Kristjanson et al., 2014). In the Ouargla context, this result also suggests that women-managed units may be organized around more intensive, closely monitored animal care within the domestic sphere, an interpretation consistent with the concentration of women's livestock management in home-based rather than farm-based settings observed in the survey. This points to a further policy lever: targeted microcredit and veterinary support for women livestock managers is not only a matter of equity, given their demonstrated productive performance, but a direct means of strengthening the economic efficiency of family livestock systems overall.

4.5. Ouargla as a transferable model for arid oasis territories

Beyond the specific case of Ouargla, this study's framework, a rural-urban gradient combined with a diversification-income model, offers a transferable lens for other Saharan and Middle Eastern oasis towns undergoing comparable urban encroachment, such as Adrar or Biskra in Algeria, Tozeur or Kebili in Tunisia, or oasis settlements bordering expanding Gulf and North African cities. What travels well from Ouargla to these contexts is threefold: first, the empirical demonstration that family livestock farming does not disappear under urbanization but reorganizes itself around confined, hardy species, principally goats, that match the joint constraints of aridity and limited space; second, the finding that the diversification-specialization trade-off is not fixed but structurally determined by land access, implying that similar oasis towns are likely to display comparable urban specialization and rural diversification patterns wherever livestock is embedded in a diversified rather than livestock-dependent regional economy; and third, the demonstrated economic contribution of women-managed livestock units, which is consistent with patterns reported elsewhere in the region and reinforces the case for gender-targeted livestock policy in comparable settings.

This transferability nonetheless has clear limits. The Ouargla model describes a sedentary, oasis-embedded livestock system operating within a diversified household economy, and its conclusions should not be extended without adaptation to extensive, mobile pastoral systems such as those of the Sahel or Central Asia, where livestock remains the dominant income source, land is managed as a commons rather than individually held, and diversification plays a more directly protective economic role (Adams et al., 2025). The Ouargla case is therefore best understood as a model for sedentary, market-embedded oasis livestock systems facing urban encroachment, rather than as a general model for arid-zone livestock farming as a whole.

4.6. Limitations of the study

Several limitations should be acknowledged when interpreting these results. First, the data are cross-sectional, collected at a single point in time (2025); they document an association between diversification, herd size and livestock income, but do not allow this relationship to be tested as a causal effect. The structural interpretation proposed above, in which diversification partly reflects land access rather than a freely chosen strategy, is consistent with the pattern observed and with the wider literature, but confirming it directly would require longitudinal or panel data capable of tracking households as their land access and herd composition change over time.

Second, the sample was built through purposive rather than random sampling, targeting households already engaged in livestock farming in order to ensure sufficient variation in herd composition and income. This Choice was necessary to meet the study's objectives, but it means the results describe the diversification-income relationship among active livestock-keeping households, and do not directly capture households that may have abandoned livestock altogether under urban pressure, a group whose experience would further inform the persistence question addressed in Section 4.1.

Third, the geographic scope is limited to four zones within a single oasis territory. The transferability discussed in Section 4.5 rests on structural parallels with other Saharan and Middle Eastern oasis towns rather than on direct empirical testing across sites, and should accordingly be read as a working hypothesis for future comparative research rather than an established finding. Finally, income data were self-reported by households and are therefore subject to the recall and reporting biases common to survey-based livestock economics research, although the consistency of the herd-size and diversification effects with diagnostic checks (Section 2.5) provides some reassurance regarding the robustness of the income model.

5- Conclusion

This study analyzed the diversification of family livestock farming systems and their contribution to household income in the Ouargla region along a rural-urban gradient, seeking not only to describe the diversification-income pattern but to explain why it takes this form and what it may imply for policy and for other arid territories.

Family livestock farming persists across the gradient, including in urban Ksar Ouargla, through a reorganization around hardy, space-efficient species, chiefly goats, rather than through a simple contraction of the activity. Diversification is significantly higher in rural areas, where larger, land-secure herds allow households several species to be combined without a proportional income penalty, while urban systems specialize under spatial necessity. Herd size is the principal determinant of livestock income, while diversification is negatively associated with it once herd size is controlled for, a pattern we interpret, consistent with our three hypotheses, as reflecting livestock's role within a diversified regional economy rather than as household's primary risk buffer; as noted in Section 4.6, this interpretation rests on cross-sectional data and would benefit from further longitudinal testing.

These results carry two policy-relevant implications, offered as working conclusions rather than firm prescriptions. First, Since the diversification-specialization pattern appears rooted in land access rather than free choice, land-secure rural households may be better served by measures consolidating specialization gains (breed Improvement, veterinary services, milk value chains), while land-constrained urban households may benefit more from risk-management instruments external to herd composition, such as microinsurance and targeted input support. Second, the higher incomes generated by women-managed livestock units support the case for gender-targeted support, including microcredit and mobile veterinary services, consistent with evidence from other African contexts.

Beyond Ouargla, this framework may offer a useful, though not yet empirically tested, starting point for other sedentary, market-embedded Saharan and Middle Eastern oasis territories facing comparable urbanization, where livestock continues to fulfil food-security and cultural functions despite its secondary economic role. In a context of climate change, economic volatility and accelerating urbanization, the ability of oasis livestock systems to combine specialization where land allows and adaptive resilience where it does not points to a mechanism that may be relevant beyond the Saharan setting, and one meriting further examination through differentiated, context-sensitive public policy.

Practical and policy implications

- **Rural areas: targeted support for specialization gains**
- Support herd-size growth and productive efficiency through subsidies for hardy goat breeds, veterinary coverage and training, capitalizing on livestock's significant contribution to household income (35% on average), while preserving a moderate degree of diversification as a food-security buffer rather than eliminating it.
- Strengthen the role of rural women through dedicated microloans, priority market access and mobile veterinary services, building on the higher performance levels already observed under their management.
- Develop milk collection and value-chain infrastructure (cold chain, local processing) to help land-secure households capture the income gains associated with larger, better-managed herds.
- **Urban areas: risk-management instruments adapted to structural specialization**

- Authorize family livestock farming in domestic courtyards under strict conditions (effluent management, herd-size limits, designated peripheral zones), recognizing that urban specialization in goats is structurally determined rather than a policy target to reverse.
- Introduce microinsurance and subsidized veterinary or feed inputs for small urban units, providing the risk-buffering function that diversification cannot realistically offer in confined spaces.
- Integrate compulsory training on hygienic, low-nuisance livestock keeping and regular municipal inspection into Saharan town-planning schemes, reconciling subsistence needs with urban quality of life.

Together, these differentiated measures translate the diversification-specialization trade-off into policy instruments matched to each zone's structural position, supporting the socio-economic sustainability of family livestock farming across the rural-urban gradient, in Ouargla and in comparable oasis territories facing similar pressures.

Statements & Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contribution

A. B. conceived and designed the study, conducted the field survey, collected the data, performed the statistical analyses, and wrote the first draft of the manuscript. All authors contributed to the interpretation of the results, critically revised the manuscript for important intellectual content, and approved the final version of the manuscript.

Data Availability

Data Availability StatementThe data supporting the findings of this study are available in the Science Data Bank repository at https://doi.org/10.57760/sciencedb.45747.

References

1. **Adams F., Mensah A., Donkor E., Ayat Ullah, Anim-Jnr A. S., Mensah J. O., Etuah S., & Appiah G. B., (2025).** Income over loss: How management systems lower mortality and increase farm incomes from small ruminants in urbanizing Africa, Small Ruminant Research, Volume 253, 2025, 107626, https://doi.org/10.1016/j.smallrumres.2025.107626

2. **Adebambo, O. A., et al. (2021).** *The resilience of Dwarf goats to environmental stress: A review*. *Small Ruminant Research, 205*, 106534. https://doi.org/10.1016/j.smallrumres.2021.106534
3. **Anim-Jnr, A. S., Sasu, P., Bosch, C., Mabiki, F. P., Frimpong, Y. O., Emmambux, M. N., & Greathead, H. M. R. (2023).** Sustainable Small Ruminant Production in Low- and Middle-Income African Countries: Harnessing the Potential of Agroecology. *Sustainability*, *15*(21), 15326. https://doi.org/10.3390/su152115326
4. **Barrett, C. B., Reardon, T., & Webb, P. (2001).** Nonfarm income diversification and household livelihood strategies in rural Africa. *Food Policy*, 26(4), 315–331. https://doi.org/10.1016/S0306-9192(01)00014-8
5. **Bekee, B., & Valdivia, C. (2023).** Resilience of Rural Households: Insights from a Multidisciplinary Literature. Sustainability, 15, 5500. https://doi.org/10.3390/su15065500
6. **Bisson, J. (2010).** *Sahara : villes et sociétés sahariennes*. Paris: Karthala.
7. **Chentouf M. (2014).** Systèmes de production caprine au nord du Maroc: Contraintes et propositions d'amélioration. CIHEAM / INRAM / FAO, 2014. p. 25-32. Options Méditerranéennes : Série A. http://om.ciheam.org/om/pdf/a108/00007050.pdf.
8. **Chniter, M., Dhaoui, A., Houidheg, A., Atigui, M., & Hammadi, M. (2024).** Socio-economic Aspects and Farming Practices of Goats in Southern Tunisia. Trop. Anim. Health Prod. , 56, 220. https://doi.org/10.1007/s11250-024-04063-2
9. **Côte, M. (2006).** *L'Algérie ou l'espace retourné*. Paris: Flammarion.
10. **Daramola, J.O., Abioja, M.O., Iyasere, O.S., Oke, O.E., Majekodunmi, B.C., Logunleko, M.O., Adekunle, E.O., Nwosu, E.U., Smith, O.F., James, I.J., Williams, T.J., & Abiona, J.A., (2021).** The resilience of Dwarf goats to environmental stress: A review, Small Ruminant Research, Volume 205, 2021, 106534. https://doi.org/10.1016/j.smallrumres.2021.106534
11. **Devendra, C. (2013).** Investments on pro-poor development projects on goats. *Small Ruminant Research*, 111, 1–9. https://doi.org/10.5713/ajas.2013.r.01
12. **Dubost, D. (2002).** Écologie, aménagement et développement agricole des oasis algériennes. Alger: CRSTRA.
13. **Ellis, F. (1998).** Household strategies and rural livelihood diversification. Journal of Development Studies, 35(1), 1–38. https://doi.org/10.1080/00220389808422553
14. **Ellis, F. (2000).** The determinants of rural livelihood diversification in developing countries. Journal of Agricultural Economics, 51(2), 289–302. https://doi.org/10.1111/j.1477-9552.2000.tb01229.x
15. **Ellis, F. (2000).** Rural livelihoods and diversity in developing countries. Oxford: Oxford University Press.
16. **FAO (2011).** *World Livestock 2011: Livestock in food security*. Rome: Food and Agriculture Organization of the United Nations.
17. **FAO (2012).** *Urban and peri-urban livestock production*. Rome: Food and Agriculture Organization of the United Nations.

18. **FAO (2018).** *Transforming the livestock sector through the Sustainable Development Goals*. Rome: Food and Agriculture Organization of the United Nations.
19. **Habib, N., Ariyawardana, A., & Aziz, A. A. (2023).** The influence and impact of livelihood capitals on livelihood diversification strategies in developing countries: A systematic literature review. Environmental Science and Pollution Research, 30, 69882–69898. https://doi.org/10.1007/s11356-023-27638-2
20. **Herrero, M., Addison, J., Bedelian, C., Carabine, E., Havlík, P. & al. (2016).** Climate change and pastoralism: impacts, consequences and adaptation. OIE Revue Scientifique et Technique 35:417–433. https://doi.org/10.20506/RST.35.2.2533
21. **Kichamu, N., Astuti, P. K., Wanjala, G., Strausz, P., Bagi, Z., & Kusza, S. (2024).** A Review on Indigenous Goats of East Africa: A Case for Conservation and Management. Biology, 13(6), 419. https://doi.org/10.3390/biology13060419
22. **Kristjanson, P., Waters-Bayer, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., Grace, D., & MacMillan, S. (2014).** Livestock and women's livelihoods: A review of the recent evidence. *ILRI Discussion Paper*. Nairobi: International Livestock Research Institute.
23. **Laouadi, M., Tennah, S., Kafidi, N., & Antoine-Moussiaux, N. (2018).** A basic characterization of small-holders' goat production systems in Laghouat area, Algeria. Pastoralism 8, 24. https://doi.org/10.1186/s13570-018-0131-7
24. **Laroussi, A., Martin-Collado, D., Atoui, A., Chibani, R., Ben Salem, F., Abdennebi, M., Doghbri, L., Jaouad, M., & Najari, S. (2026).** Pastoral Farming Systems in Arid Regions: Typology of Small Ruminant Farms in Southern Tunisia. *Animals*, *16*(6), 902. https://doi.org/10.3390/ani16060902
25. **Loison, S. A. (2015).** Rural livelihood diversification in Sub-Saharan Africa: A literature review. Journal of Development Studies, 51(9), 1125–1138. https://doi.org/10.1080/00220388.2015.1046445
26. **Mashamaite, P. K., and Tada, O. (2025).** Phenotypic plasticity in trait performance of common dairy goat breeds under diverse environments: a systematic review. Front. Anim. Sci. 6:1640241. https://doi.org/10.3389/fanim.2025.1640241
27. **McDermott, J. J., Staal, S. J., Freeman, H. A., Herrero, M., & Van de Steeg, J. A. (2010).** Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science*, 130(1–3), 95–109. https://doi.org/10.1016/j.livsci.2010.02.014
28. **Meza-Herrera, C. A., Navarrete-Molina, C., Macias-Cruz, U., Arellano-Rodriguez, G., De Santiago-Miramontes, A., Sariñana-Navarrete, M. A., Marin-Tinoco, R. I., & Perez-Marin, C. C. (2024).** Dairy Goat Production Systems: A Comprehensive Analysis to Reframe Their Global Diversity. *Animals*, *14*(24), 3717. https://doi.org/10.3390/ani14243717
29. **Monau, P., Raphaka, K., Zvinorova-Chimboza, P., & Gondwe, T. (2020).** Sustainable Utilization of Indigenous Goats in Southern Africa. *Diversity*, *12*(1), 20. https://doi.org/10.3390/d12010020
30. **Peacock, C. (2005).** Goats – a pathway out of poverty. *Small Ruminant Research*, 60, 179–186. https://doi.org/10.1016/j.smallrumres.2005.06.006

31. **Thornton, P. K. (2010).** Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B*, 365, 2853–2867. https://doi.org/10.1098/rstb.2010.0134
32. **Toutain, G. (1979).** *Éléments d'agronomie saharienne : de la recherche au développement*. Paris: INRA.

Figures

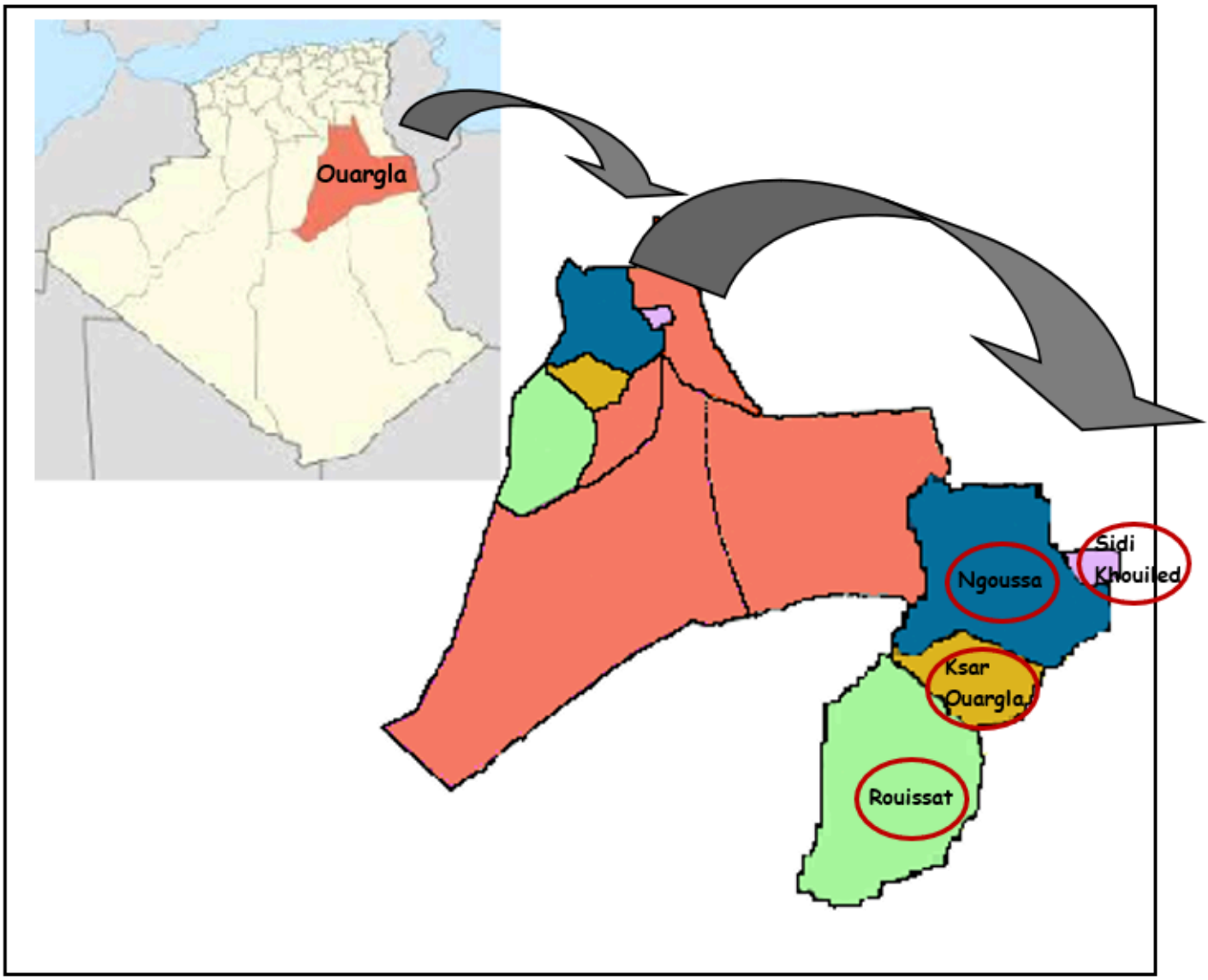

Figure 1

Location of the study areas in the Ouargla region.

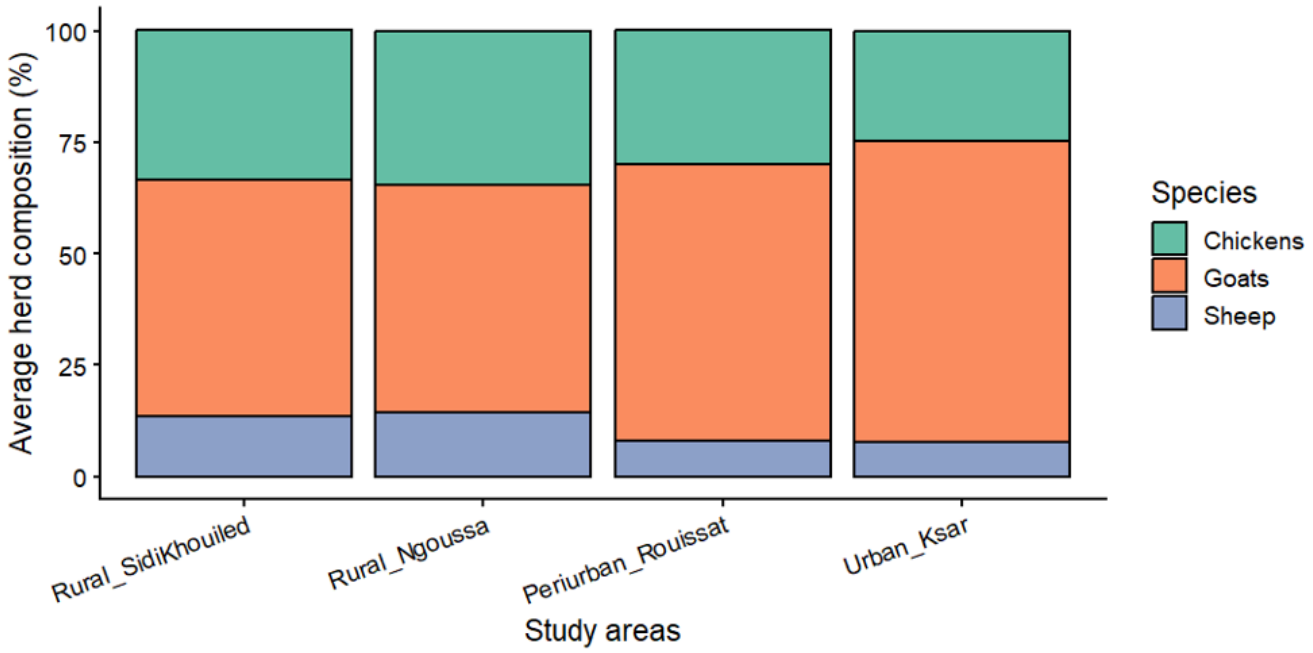

Figure 2

Structure of family livestock farming by study area

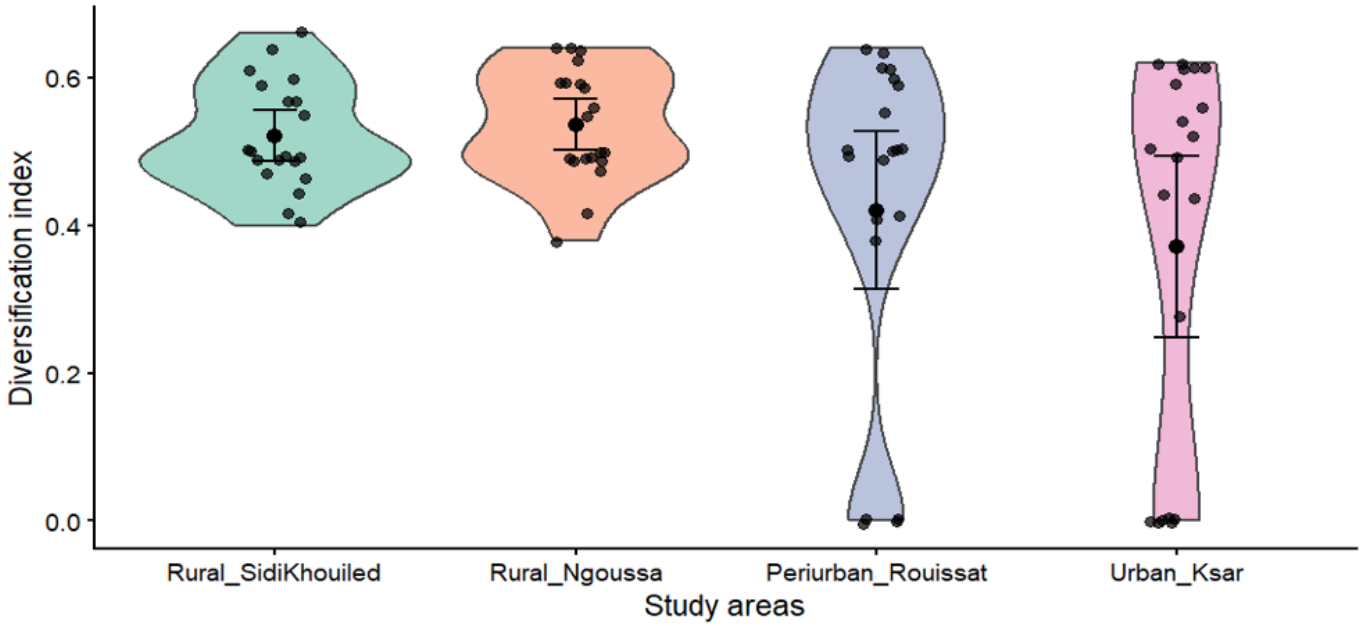

Figure 3

Diversification index by area

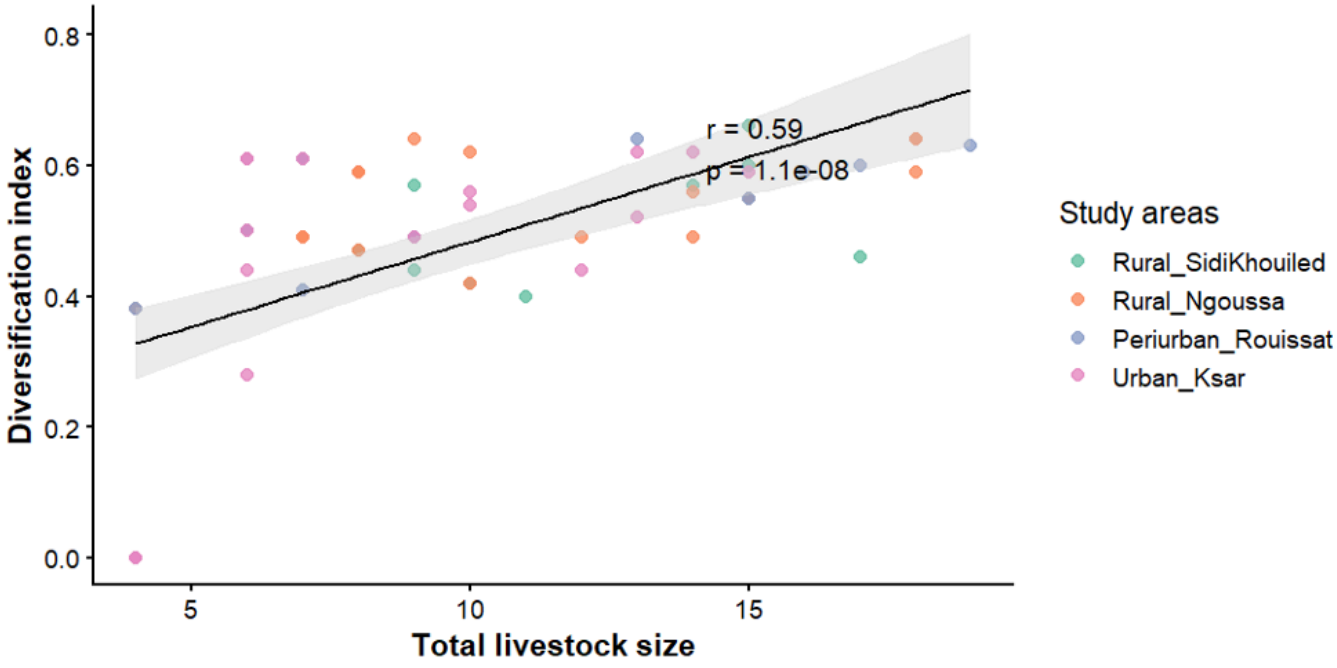

Figure 4

Relationship between herd size and diversification

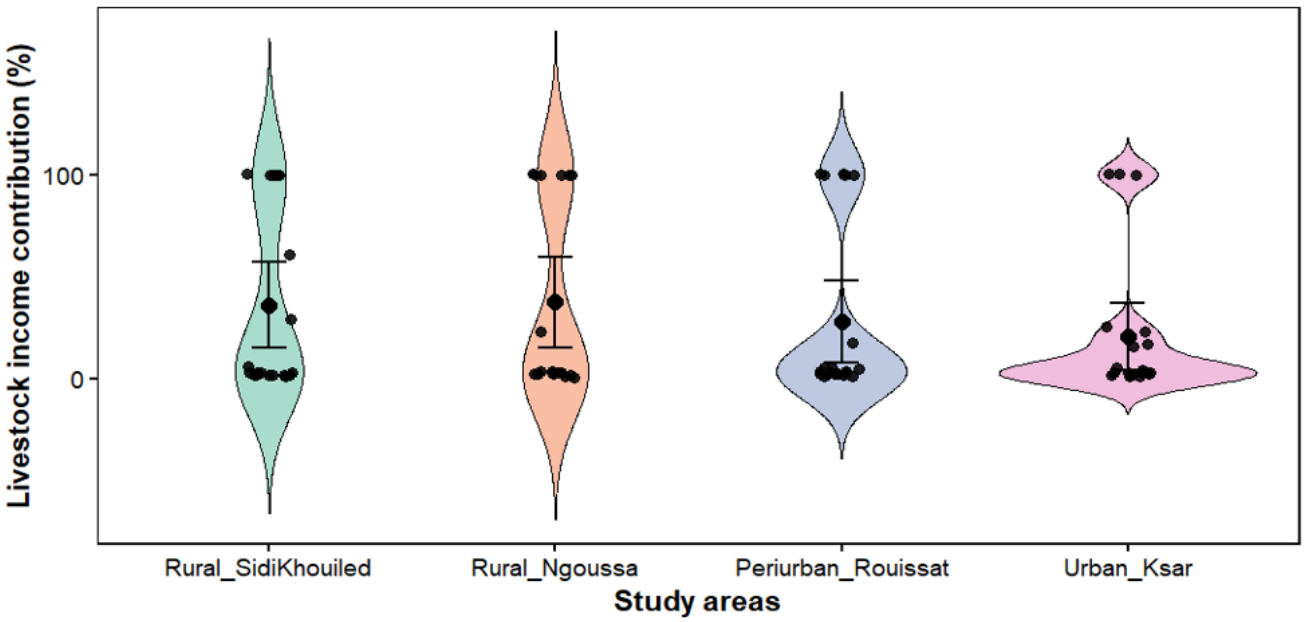

Figure 5

Contribution of livestock farming to household income