Original Article

Climate Resilience in Northern Jordan's Small Ruminant Production: Strategies for Sustainable Adaptation

R. Awad * [1], A. Mohamed-Brahmi [2], H. Titi [3], M. Jaouad [4], A. Gasmi-Boubaker[1]

[1] Department of Animal Production, National Agronomic Institute of Tunisia, Carthage University, Tunis, 1082, Tunisia.

[2] Higher School of Agriculture of Kef, Laboratory for the Sustainability of Production Systems in the North-West Region, University of Jendouba, Kef, 7119, Tunisia.

[3] Department of Animal Production, Faculty of Agriculture, The University of Jordan, Amman, 999045, Jordan

[4]Institute of Arid Regions Médenine, Laboratory of Economy and Rural Societies, Médenine, 4119, Tunisia.

Abstract

Climate change poses a significant threat to small ruminant farming globally, and understanding farmers' perceptions and adaptive strategies is crucial for developing effective resilience measures. This study hypothesizes that farmers' perceptions of climate change, their management practices, and demographic factors influence their capacity to adapt and sustain small ruminant production in Northern Jordan. To test this, we conducted a survey with 272 farmers complemented by focus group discussions across four regions. Results showed that the majority of farmers reported increases in temperature coupled with reductions in both rainfall and rangelands in both short and long term. Despite those observations, only 55 percent of farmers expressed concern in climate change. In addition, while many had begun implementing mitigation measures, over 70 percent had not yet made any changes to try and address these changes. Interestingly, a large number of local breed farmers stated that they appreciated the native breeds for their climatic adaptability and local environmental suitability, and they had also adjusted grazing and feeding management practices accordingly. Additionally, those reasons suggested that most farmers were responsive to change.

Keywords: Small Ruminants, Climate Change, Resilience, Sustainable Management, Northern Jordan

Address for Correspondence:
Rula Awad, Department of Animal Production, National Agronomic Institute of Tunisia, Carthage University, Tunis, 1082, Tunisia.
Email: rula.a.awad@gamil.com

Received: 2025-04-05 **Accepted**: 2025-12-08 **Published**: 2026-03-31

Introduction

Small ruminants' production which includes goats and sheep is essential to global agriculture (28). Nevertheless, this industry is progressively facing issues due to climate change (4). The effects of climate change are becoming more and more visible in Jordan through rising temperatures, changes in precipitation, and greater frequency of severe weather conditions (10;14). The consequences of climate change on small ruminant production are apparent in multiple forms. Increased temperature along with change in precipitation pattern and rise in frequency of severe climatic events is leading to heat stress, resource depletion particularly water, altered

www.ajas.uoanbar.edu.iq

How to cite this article: Awad, R., Mohamed-Brahmi, A., Titi, H., Jaouad, M., and Gasmi-Boubaker, A (2026). Climate Resilience in Northern Jordan's Small Ruminant Production: Strategies for Sustainable Adaptation. Anbar Journal of Agricultural Sciences, 24(1): 157–171.DOI-Crossref: 10.32649/ajas.2026.191227

forage production, and drastic limitation of pastureland and its nutritional value (16; 19; 21). Moreover, climate change is causing changes in the distribution of pests and diseases which is bound to adversely affect the health and production of small ruminants (15;20). To cope with these challenges, farmers may need to implement a range of strategies, such as improving livestock housing and ventilation to reduce thermal stress, conserving water, and adjusting feeding practices (11; 24). Breeding programs can also help mitigate the effects of climate change by selecting animals for traits such as heat tolerance, disease resistance, and feed efficiency (26).

Despite the recognized importance of small ruminant farming in Northern Jordan, particularly for rural livelihoods and food security (7), there remains a significant gap in research regarding the local impacts of climate change on this sector and the strategies farmers are using to adapt. While studies from Lebanon (11), Cameroon (31), Nigeria (9), and Ethiopia (2) have explored similar issues, Jordan is underrepresented in the literature.

There is a critical need to understand how small ruminant farmers in Northern Jordan are perceiving and responding to climate change, what adaptation strategies they employ, and the barriers they face in sustaining their livelihoods.

This study aims to: Assess small ruminant farmers' perceptions of climate change and its impacts in Northern Jordan; Identify the adaptation strategies currently used by farmers to cope with climate-related challenges; Analyze the demographic and management factors influencing farmers' ability and willingness to adapt; and Provide recommendations for enhancing adaptive capacity and resilience in the small ruminant sector.

By centering on farmers' experiences and strategies, this research provides insights that can inform local policy and practical interventions to support sustainable small ruminant production under changing climatic conditions.

Materials and Methods

The study was carried out in Northern Jordan (32°25'6.96"N, 38°18'59.66"E) during the year 2021 (Figure 1 a). The study area is well-known for its diverse geographic features and climate which ranges from the Mediterranean climate in the western governorates (Irbid, Jerash, and Ajloun), to the desert climate in the rest of northern Jordan (Mafraq governorate), with annual precipitation below 200 mm (Figure 1b). Over 90% of the northeastern desert is part of the Arabian desert and stretches to border Syria on the north, and Iraq and Saudi Arabia to the east (1).

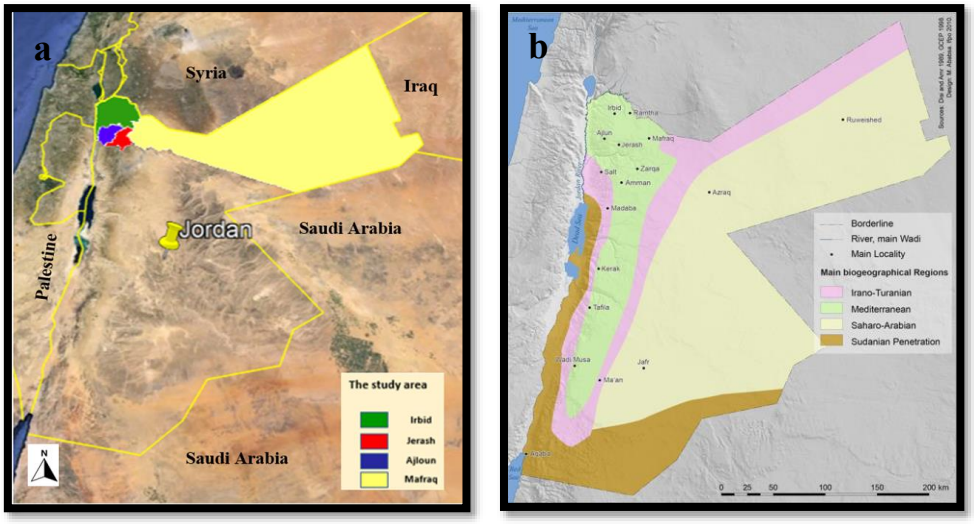

Fig. 1. The Study Area (a) Irbid, Jerash, Ajloun, and Mafraq Governorates; b) Main Biogeographical Regions (1).

A cross-sectional survey was conducted with a sample of 272 of 11,360 small ruminant holders from four governorates in the region, specifically Irbid, Jerash, Ajloun, and Mafraq. The sample size was calculated using Steven K. Thompson's formula for finite populations, assuming a 95% confidence level, 5% margin of error, and 50% expected response rate (27). Small ruminant holders were selected using stratified random sampling methodology (18), with 89 individuals from Irbid, 16 from Ajloun, 29 from Jerash, and 140 from Mafraq. The variation in sample size reflects the actual distribution of small ruminant holders across these governorates, with Mafraq having a significantly higher livestock population. This regional disparity was taken into account during analysis through stratification and, where appropriate, weighting procedures (18). The survey instrument was developed to cover a range of topics including farmer demographics, livestock management practices, climate change impacts, resilience strategies, and expectations for sustainable management approaches.

In addition to the survey, three focus group discussions were held in different regions within the study area, specifically in Kufranja District in Ajloun, Ruwashied, and North-Western Badia districts in Mafraq. The detailed discussions involved a selected set of farmers and other interested stakeholders to further learn about their perceptions and experiences of climate change concerning sustainable agricultural management. Historical temperature data from the past 20 years of Northern Jordan were obtained from the Arabia Weather Company database in order to identify the trends and patterns of climate change in the region. Arabia Weather was selected for its detailed regional coverage and consistent, localized reporting that aligns closely with observed climate patterns in the study area.

The data collected from both the survey and focus group discussions were analyzed using descriptive and inferential statistical methods in IBM SPSS Statistics software version 20. Descriptive statistics were employed to summarize the demographic characteristics of the small ruminant holders, as well as their perceptions of climate change impacts and resilience strategies. Inferential statistics, such as Chi-square tests and correlation analysis, were utilized to explore the relationships between variables and identify significant factors influencing farmer expectations and efficiency in adapting to climate change. All statistical tests were conducted at a 95% confidence level, and results with p-values < 0.05 were considered statistically significant.

Results and Discussion

1. Trends and patterns of climate change in the Northern Jordan

Due to the lack of region-specific long-term precipitation data, national-level rainfall data for Jordan was used to illustrate general trends. Given that Northern Jordan shares representative climatic characteristics with the rest of the country—particularly the balance between Mediterranean and arid zones—this approach provides a reasonable proxy for understanding precipitation variability in the study area.

Based on the recorded average precipitation (mm) of Jordan (Figure 2), it can be observed that there were fluctuations in the rainfall rates from year to year. Rainfall for the whole country between 2008 and 2022 was variable with an average value around 100mm. The lowest recorded value of was 53.23mm in 2017 to a high of 145.46mm in 2020. The highest rainfall rates were recorded in 2020, 2022, and 2003, while the lowest rates were observed in 2017 and 1999. No clear trend was observed in the historical rainfall data. (29) confirmed this variability in their study, noting that annual rainfall in Jordan varied between wet and drought seasons, with extreme events possible. Their study identified 1999 as the most drought-stricken year from 1960 to 2010.

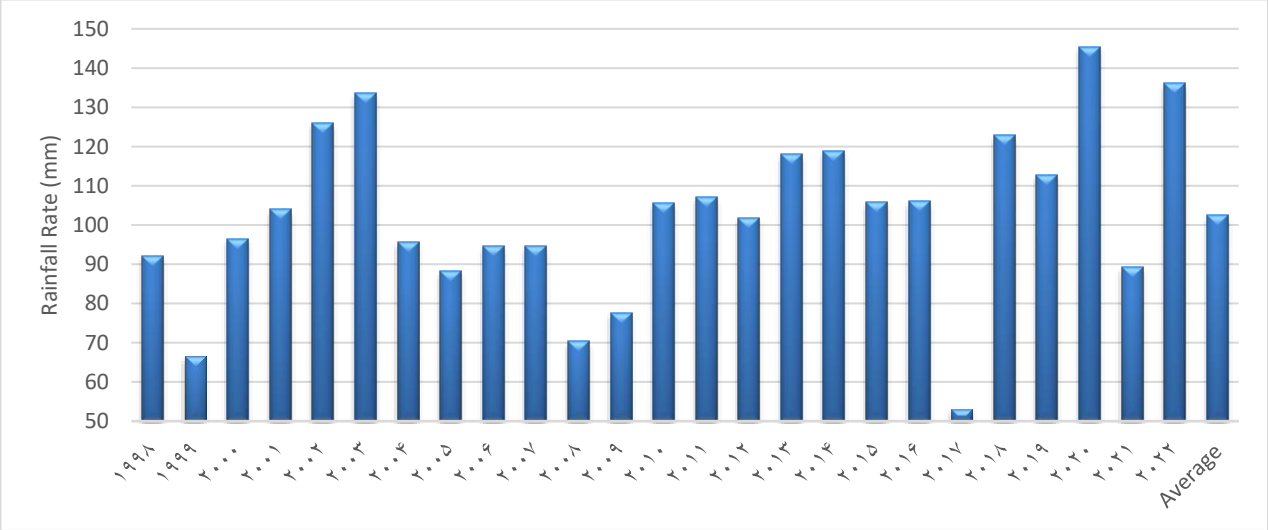

Fig. 2. The historical average precipitation (mm) of Jordan (32)

Similarly, the historical temperature data for Northern Jordan from 2000 to 2021 (Figure 3 and Figure 4), based on raw daily records obtained from the Arabia Weather database, demonstrates variations in temperatures throughout the years, with no clear trend observed. The average temperature for the region was around 19.6°C, with fluctuations observed from year to year. A typical seasonal pattern in temperature changes was reported with January and February being the coldest months and August being the hottest month. Analysis of the temperature data reveals instances of extreme weather events, as indicated by deviations from the average temperatures. The average temperature spiked to 30.0 °C in June 2016, signaling a potential heatwave or extreme weather event for that month. Similarly, in December 2014, an average temperature of 17.5°C was recorded, notably higher than the typical temperature for that month, suggesting abnormal climate patterns or extreme weather conditions.

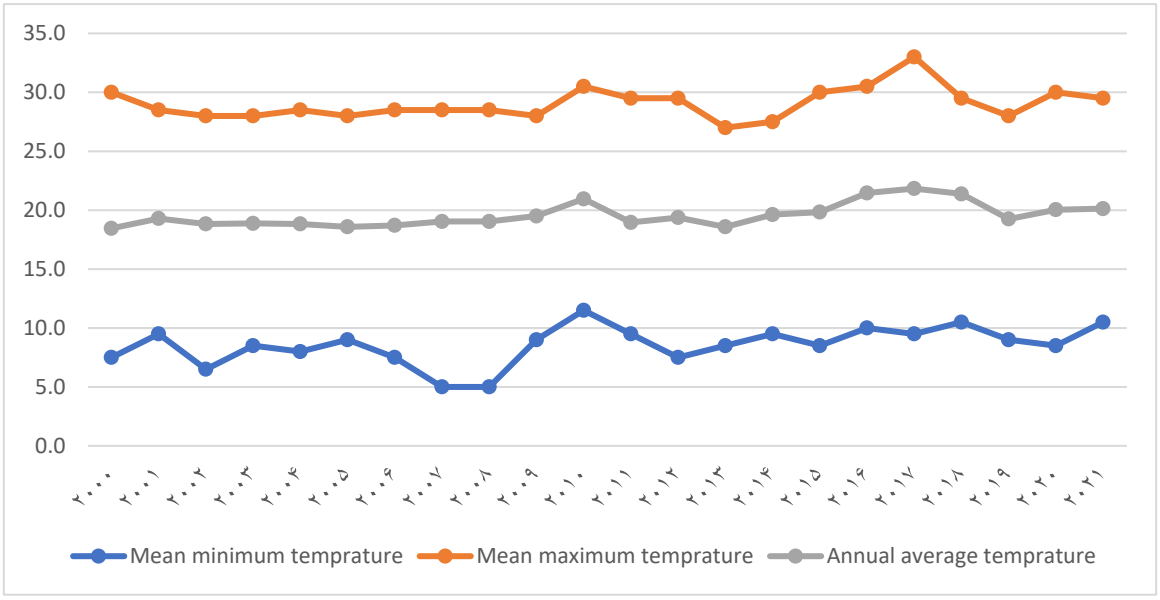

Fig. 3. The historical average air temperature (OC) per year in the Northern Jordan

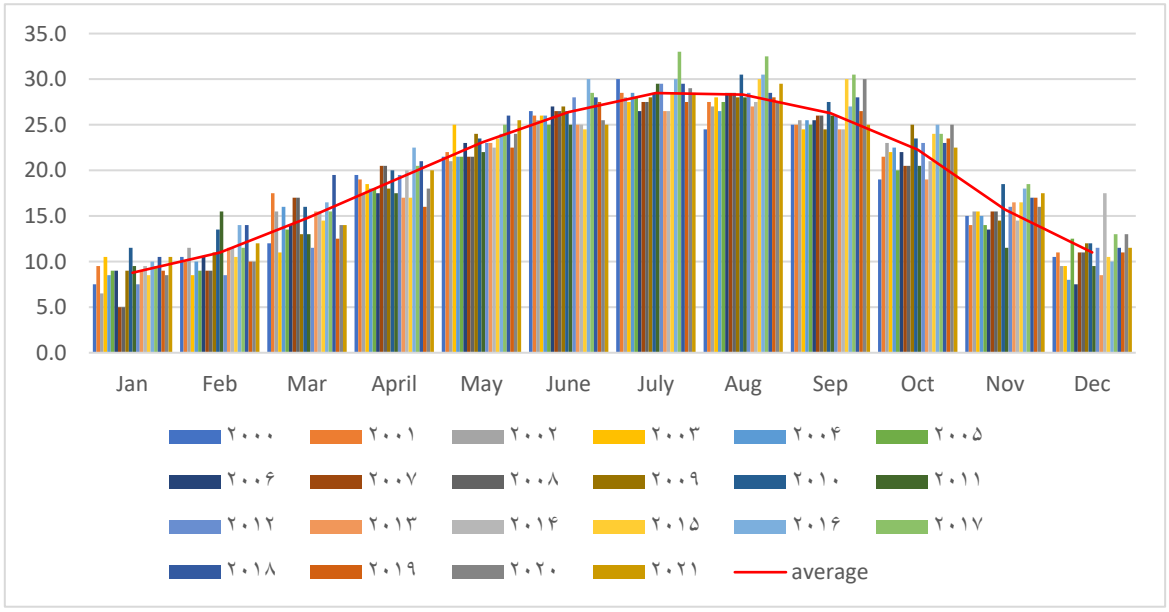

Fig. 4: The historical average air temperature (OC) per month in the Northern Jordan

These fluctuations in weather patterns are a big challenge for water resource management and agricultural procedures in Jordan, affirming the significance of monitoring and adapting to the changes in climate. Similar patterns and concerns have been reported in studies conducted in both the United States and Jordan, including a combination of climate modeling and observational analyses. For instance, (22) conducted a synthesis and simulation-based study using climate models to assess the interactive effects of reactive nitrogen and climate change on aquatic ecosystems and water resources in the United States. In Jordan, (25) performed an observational analysis based on long-term climate and hydrological records to evaluate the impacts of climate change on national water availability. Likewise, (3) used the AquaCrop model supported by field data to simulate the potential effects of climate change on rainfed barley production in a semi-arid

Jordanian basin. The changing precipitation patterns and increasing temperatures identified in our study are consistent with the findings of these studies. Moreover, the impacts on water availability and agricultural productivity, especially for vulnerable crops such as barley, are clearly evident in both our results and the supporting literature.

2. Perceptions and causes of climate change among small ruminant holders in the Northern Jordan

The study findings showed that a majority of small ruminant holders (82%) were aware of long-term changes in temperature as 60% of them noted a general increase in temperature and 18% observed warmer summers and colder winters. Additionally, 4% reported fluctuations in temperature and seasonal changes. Furthermore, 96% of participants observed changes in long-term rainfall rates, with 91% noting a decrease in rainfall and 5% observing changes in the timing of rainy seasons. The results also revealed that 52.9% of sheep and goat holders experienced severe extreme temperature spikes and/or decreases in rainfall that directly affected their rangelands in the years 1999, 2017, and 2021. Overall, the farmers' perception about climate change in Northern Jordan aligns with the meteorological data (Figure 1, 2), which confirm rising temperatures and declining rainfall trends over time. Similar findings were reported by the focus group discussions indicated that the region had observed an increase in temperature and a decrease in precipitation over the last two decades. These changes have resulted in inconsistent and irregular rainfall patterns, with lower quantities and higher temperatures recorded over extended periods. Small ruminant holders have also noted variability in rain distribution, timing, and duration, with rainy seasons starting and ending earlier, sporadic rainy periods, and overall unpredictability in rainfall patterns. Furthermore, they reported that the combination of high temperatures and low rainfall which caused detrimental effects on the growth, maturity, quality, and quantity of natural pastures. This has resulted in fodder shortages, particularly during the prolonged dry season.

Present results also showed that 94% of farmers reported negative impacts on rangelands in the past 20 years as 74% experienced a decrease in rangeland areas, 10% faced complete drying up of rangelands, and some observed a decline in pastoral plant species. Moreover, 29% of farmers attributed these changes to increasing frequency and severity of droughts, believing it was a result of changing rainfall patterns and longer periods of dry weather due to climate change. Meanwhile, 6% of farmers attributed the deterioration of natural resources to desertification and urbanization. These observations align with findings from a study by (8) in the Al-Ruwaished region of northern Jordan. However, the impact on rangelands differed as the study revealed a significant absence of pastures due to successive years of drought and natural phenomena like sandstorms. This was closely linked to the region's distinct geographical characteristics, including its low annual rainfall (<150 mm), flat topography, high exposure to prevailing winds, and fragile sandy soils prone to erosion. Similarly, farmers in the northeastern desert of Jordan also noted lower rainfall and higher temperatures leading to negative effects on rangelands (6). These findings were somewhat consistent with perceptions of farmers in the Borana lowlands of Ethiopia as reported by (12).

While a portion of the participants (54%) did not perceive a direct impact of climate change on their livelihoods, notable differences emerged based on their level of experience. For instance, around 18% of farmers with less than 10 years' experience and over 50% of those with more experience agreeing with the proposition. However, 56% of participants recognized climate change as a pressing issue today, and 60% expressed interest in learning about its effects on the small ruminant sector in Jordan. Additionally, 15% viewed climate change as a natural occurrence beyond human influence, while

22% attributed it significantly to human activities. Furthermore, 30% believed that natural phenomena are exacerbated by human actions, leading to climate change. Age was also a significant factor in participants' beliefs about the main cause of climate change, with older farmers being more inclined (39%) to attribute it to human practices compared to middle-aged (18%) and young farmers (17%). In contrast, 40% of middle-aged farmers believed that climate change is a result of both human practices and natural factors, compared to 11% of young farmers and 7% of old farmers. While the reasons for the mixed perceptions among participants regarding the effects of climate change on their livelihoods and the complexity of beliefs and attitudes toward climate change are challenging to articulate, it is possible that other urgent concerns or difficulties, such as economic pressures or market fluctuations, take precedence in the daily lives of these farmers. Consequently, they may prioritize addressing these immediate issues over considering the long-term implications of their actions on the environment and climate change. Despite some farmers' lack of awareness, the acknowledgment of climate change as a critical issue and the demonstrated interest in understanding its impacts on the small ruminant sector in Jordan suggest a willingness to educate themselves and adapt to potential challenges. In comparison, previous studies conducted in Borana, southern Ethiopia (12) found that supernatural forces were cited as the major driver of climate change by 45% of respondents, followed by natural (physical) processes at 33%, and human-induced deforestation at 16%. In Gera District, Jimma District, Oromia Regional State, Southwestern Ethiopia (2), ranchers attributed climate change to various causes such as human activity and natural processes (47.2%), human activity (28.2%), natural processes (12.7%), and God's wrath due to human sins (11.9%). On the other hand, a study conducted in Türkiye (23) found that most respondents believed that climate change (93.1%) is caused by both natural and human causes.

3. Demographic profile of small ruminant holders in the Northern Jordan

The characteristics of the small ruminant holders revealed that most breeders were located in Mafraq Governorate, followed by Irbid, Jerash, and Ajloun Governorates (Table 1). The small ruminant population in the study area was about 1,076,758 head of sheep and 210,306 head of goats distributed among 11,405 farmers. Farmer's age averaged 52 years with 58% falling into the middle-aged category, 23% being over 60 years, and 19% being young people (15- 40 years).

Present results indicated that a high proportion of individuals in the study area were middle-aged or older. Based on previous finding, this demographic trend may reflect a greater potential for awareness of climate change and its impacts on small ruminant production, as older farmers are more likely to have accumulated long-term experience and exposure to climatic variations (2). In terms of education, 6% had certificates above high school, 18% had high school qualifications, and 31% did not have high school qualifications. Additionally, 18% were only able to read and write, while 27% were illiterate. The majority of farmers had an average of 31 years of experience in agriculture, with their main activities involving raising small ruminants beside producing crops. Around 22% owned large flocks of over 500 heads, 46% had medium flocks of 100-499 heads, and 32% had small flocks of less than 100 heads. Regarding livestock ownership, 51% owned both sheep and goats, 36% owned sheep only, and 13% owned goats only. The majority of sheep breeders owned Awassi sheep, while the majority of goat breeders owned Baladi (local) goats. The utilization of local breeds by small ruminant producers in the region reflects an important strategy for sustainable adaptation to climate change, as supported by (30) who underscore the significance of landraces in facilitating environmental adaptation in the face of changing climate conditions.

Half of farmers used a semi-extensive production system, 42% used an extensive system, and 8% used an intensive system

These findings suggest that a significant portion of farmers are susceptible to the effects of climate change. Specifically, climatic variables such as temperature and rainfall patterns play a crucial role in determining the availability of pastures and other essential resources for livestock throughout the year (33). Of those interviewed, 46% kept their animals in barns, 32% in temporary structures, and 22% in open areas. A total of 73% of the farmers regularly vaccinate their animals, 9% when necessary, and 17% did not vaccinate their animals. This study on small ruminant production in Northern Jordan showed that most farmers are vaccinating their animals against disease outbreaks. This is a positive and encouraging indicator, as vaccination plays a critical role in effective disease control and in minimizing potential losses that could result from increased disease incidence under changing climatic conditions (21). As shown by (17), this points to the complex interactions between climatic variables and disease outbreaks in livestock. There are direct effects of climate on the distributions of diseases — i.e., increased vector activity in higher temperatures — and indirect influences like the "tolerance" and "susceptibility" of various animal breeds. This means that farmers' decisions to vaccinate their animals may be based on a combination of factors including their perceptions of disease risk, as well as the overall impact of climate change on disease outbreaks.

Table 1. Demographic profile of Small Ruminant holders in the Northern Jordan

Category	%	Category	%
Location of small ruminant breeders		**Type of small ruminant holdings**	
Mafraq Governorate	54	Sheep and goats	51
Irbid Governorate	30	Sheep only	36
Jerash Governorate	10	Goats only	13
Ajloun Governorate	6		
Age of farmers		**Sheep breeds owned**	
Young adults (15- 40 years old)	19	Only Awassi sheep	93
Middle-aged (40-59 years old)	58	Other breeds besides Awassi	6
Old- aged (Over 60 years old)	23	Breeds other than Awassi	1
Education of farmers		**Goat breeds owned**	
Above high school	6	Local goats	83
High school (Tawjihi)	18	Desert goats	7
Did not obtain high school (Tawjihi)	31	Other breeds	19
Read and write	18		
Illiterate	27		
Involvement in farming activities		**Production system used**	
Raising small ruminants and producing crops	54	Semi-extensive	50
Raising small ruminants only	46	Extensive	42
		Intensive	8
Flock holdings		**Housing for animals**	
Large flocks (>500 heads)	22	Barns	46
Medium flocks (100-499 heads)	46	Temporary structures	32
Small flocks (<100 heads)	32	Open area	22
Experienc		**Vaccination of animals**	
(average in years)	31	Regular basis	73
		When necessary	9
		Did not vaccinate	17

4. Small ruminant holders' strategies for withstanding historical climate change

Table 2 presents the strategies used by small ruminant farmers to adapt to variations in

climate over time, as well as the modifications made to their herd management practices in the past five years. It also shows the relationship between the actions taken by farmers to mitigate longer-term changes in weather patterns and the adjustments made to their practices in the last five years, as measured by the correlation coefficient (r value). The majority of respondents (73%) did not take any action to adapt to historical weather shifts This can be explained by that they may be accustomed to dealing with weather shifts in a certain way and may not see the need to change their approach. Most small ruminant holders (70.4%) also did not make any changes in the past 5 years. However, farmers who did not adapt to climate variations over time were less likely to continue this trend in the past 5 years. This could indicate a possible shift in mindset or awareness among farmers regarding the need to adapt to climate variations. The most common strategies implemented by farmers to adapt to climate variations were modification of feeding management and adjusting grazing periods. Both of these strategies were positively correlated with changes in herd management practices in the past 5 years. Changing rangelands, adjusting grazing periods, and modifying farm infrastructure were also commonly used strategies. Among these strategies, adjusting herd size showed the highest increase in response in the past 5 years. However, there was a weak negative correlation between adjusting herd size and other adaptation strategies. Participants in the discussion groups stated that the Ministry of Agriculture in Northern Jordan has implemented strategies such as water harvesting through water excavations in Mafraq Governorate (Figure 5) and permitting grazing on forest lands in the Ajloun region to support small ruminant production in the face of historical climate change. They also noted that the governorate provided feed support to farmers through the Environmental Compensation Project during the previous dry seasons. Additionally, the Ministry of Agriculture is considering incorporating drought-resistant alternative fodder projects in its future plans. In comparison, (2) and (9) studies in southwest Ethiopia and Nigeria found that diversification of livestock species, feed conservation, reducing herd sizes, water harvesting, provision of supplementary feeds, and forage production were common adaptation strategies. Interestingly, farmers in Nigeria also utilized planting trees for shade, feeding animals with grains and concentrates, and storing grass for the dry season as key adaptation practices (9). These results suggest that different regions employ various strategies to cope with climate change challenges in the livestock sector.

Table 2. Small ruminant holders' adaptation strategies to weather shifts in Northern Jordan

Adaptation strategies	Responses				P value	r value
	Against historical weather shifts		In past 5 Years			
	Number	%	Number	%		
No action	200	60.8	193	55.1	0.071	-0.110
Modification feeding management	43	13.1	27	7.7	**0.016**	**0.147**
Changing the rangelands	18	5.5	19	5.4	0.108	-0.098
Adjusting grazing periods	38	11.5	31	8.9	**0.013**	**0.151**
Adjust herd size	1	0.3	40	11.4	0.525	-0.039
Adjusting farm infrastructure	27	8.2	38	10.9	0.815	0.014
Other	2	0.6	2	0.6	**0.026**	**0.136**
Total	329	100	350	100	0.071	0.110

Fig 5. Water harvesting in the Northern Jordan: (a) water excavation located in the East-Northern Badia district; (b)

water excavation located in AL-Ruwaished district

Table 3 illustrates the correlation between the demographics of small ruminant breeders in Northern Jordan and how they have adapted to historical weather changes and climate shifts over the last five years. The results indicate a significant positive correlation between the geographic location of breeders and their strategies to adapt ($r = 0.150$, $p = 0.013$), whereby breeders in Ajloun Governorate (44%) tend to implement measures against long-term weather changes more than those in Irbid (36%), Jerash (24%), and Mafraq (20%). Small ruminant holders in Ajloun may be more aware of the impacts of climate change due to their colder climate. Accordingly, they would be motivated to change their seasonal strategies and some combination of cultural and socio-economic factors might explain why some small ruminant holders are more inclined to alter their climate change mitigation strategies across the governorates. Moreover, there is a significant positive correlation between experience and adaptation strategies in the past five years ($r = 0.148$, $p = 0.014$), meaning that more experienced breeders are willing to make alterations for recent climate changes. Specifically, breeders who confine their livestock in barns (36%) show greater willingness to adjust their strategies than those who use temporary structures (29%) and open areas (12.5%), which is supported by a statistically significant negative correlation between housing type and adaptation strategies ($r = -0.184$, $p = 0.014$). While factors such as age, education level, flock size, type of small ruminant holdings, and production system did not show a significant correlation with adaptation strategies. The results of the study align with (5) findings that suggest factors such as experience and geographic location play a significant role in farmers' adoption of adaptation strategies against climate change. However, the study also found that factors such as age, education level, flock size, and type of small ruminant holdings did not show a significant correlation with adaptation strategies, which is consistent with the findings in the study conducted in Karaman province (13). These results highlight the complex and multifaceted nature of climate adaptation decisions among farmers and the importance of considering a range of factors that can influence their behavior.

Table 3. The correlation between the Demographic profile and adaptation strategies of the small ruminant holders in the Northern Jordan to climate change

Demographic profile	Adaptation strategies against historical weather shifts		Adaptation strategies in the past 5 Years	
	r value	P value	r value	P value
Location of small ruminant breeders	**0.150**	**0.013**	-0.062	0.213
Age of farmers	-0.063	0.301	0.034	0.575

Education of farmers	0.085	0.161	-0.098	0.108
Flock holdings	0.019	0.758	0.048	0.434
Experience	-0.033	0.582	**0.148**	**0.014**
Type of small ruminant holdings	0.090	0.136	-0.012	0.844
Production system used	-0.034	0.578	0.028	0.652
Housing for animals	0.013	0.863	**-0.184**	**0.014**
Vaccination of animals	-0.039	0.528	**0.257**	**0.000**

Correlation is significant at the 0.01 level (2-tailed). Correlation is significant at the 0.05 level (2-tailed)

5. Potential changes in adaptation strategies for small ruminant holders in the Northern Jordan

The results in table 4, suggest that a majority of small ruminant holders (79%) in Northern Jordan are willing to make changes to their current practices to adapt to changing conditions. The most commonly mentioned adaptation strategies include adjusting grazing periods, changing rangelands, adjusting herd size, and modifying feeding management. However, a small number of participants expressed a preference for taking no action. It can be explained that this willingness to change is driven by the recognition that climate change is affecting traditional production practices and impacting the availability of grazing land and water resources. Small ruminant holders understand that they need to adapt in order to ensure the sustainability of their livelihoods.

Table 4. Potential changes in adaptation strategies for small ruminant holders in the Northern Jordan

Adaptation strategies	Responses	
	Number	%
No action	58	6.8
Adjusting grazing periods	176	20.7
Changing the rangelands	170	20.0
Modification feeding management	128	15.1
Adjust herd size	169	19.9
Changing work activity	111	13.1
Other	37	4.4
Total	849	100

Multiple responses

Conclusion

Climate change poses significant challenges to small ruminant production in Northern Jordan due to unpredictable weather patterns and extreme climatic events. This study revealed that many farmers are aware of long-term shifts in temperature and rainfall and recognize the need for adaptation. While access to detailed data and formal adaptation strategies remains limited, a considerable number of farmers have shown openness to modifying their practices in response to climate pressures. Adaptation measures observed include changes in grazing schedules, rangeland use, herd size, and feeding strategies. Key factors influencing these responses include geographical location, farming experience, housing systems, and livestock type. Notably, the preference for local breeds was identified as a valuable strategy for sustainable climate adaptation.

Based on the study findings, the following recommendations are proposed to enhance the resilience of small ruminant holders in Northern Jordan to climate change impacts:

1. Enhance Farmer Awareness and Education: Develop targeted awareness campaigns and practical training programs to improve farmers' understanding of climate

change impacts and adaptation options. Emphasize the importance of adjusting herd management, modifying grazing patterns, and the benefits of using local breeds such as Awassi sheep and Baladi goats, which are better suited to harsh climatic conditions.

2. Support and Facilitate Access to Resources and Technologies: Strengthen collaboration with government agencies, NGOs, and research institutions to provide technical support, financial assistance, and access to improved livestock management technologies. This includes promoting sustainable grazing methods, implementing water harvesting systems, and investing in climate-resilient infrastructure (e.g., livestock shelters, feed storage).

3. Promote the Use of Local Breeds and Resilient Livestock Systems: Encourage the conservation and use of climate-resilient local breeds, such as Awassi sheep and Baladi goats. Support this through structured breeding programs, veterinary outreach services, and improved animal housing to reduce heat stress and disease vulnerability under changing climatic conditions.

4. Strengthen Institutional Support and Farmer Networks: Establish dedicated platforms or local agricultural hubs that enable farmers to share experiences, receive real-time weather updates, and access expert guidance. Community-based adaptation networks can enhance local knowledge exchange and promote cooperative resilience strategies.

5. Encourage Data-Driven and Region-Specific Adaptation Policies: Policymakers should base climate adaptation strategies on both scientific data and farmer experiences. Develop localized action plans that consider the specific climatic, geographic, and socio-economic conditions of each governorate, particularly those most vulnerable to climate impacts like Mafraq and Ajloun.

6. Integrate Climate Adaptation into National Agricultural Policy: Mainstream climate change adaptation into national agricultural development plans and livestock production strategies. This includes institutionalizing farmer support mechanisms such as emergency feed supply during droughts, subsidies for infrastructure improvements, and incentives for adopting adaptive practices.

Funding
This research received no external funding.

Institutional Review Board Statement
The study was conducted in accordance with the protocol authorized by the University of Jordan.

Informed Consent Statement
No Informed Consent Statement.

Data Availability Statement
No Data Availability Statement.

Conflicts of Interest
The authors declare no conflict of interest.

References

1. Ababsa, M. 2014. Terrain and formations. Atlas of Jordan. p. 42-46. https://books.openedition.org/ifpo/7683#tocfrom2n4
2. Abazinab, H., Duguma, B. and Muleta, E. (2022). Livestock farmers' perception of climate change and adaptation strategies in the Gera district, Jimma zone, Oromia Regional state, southwest Ethiopia. Heliyon, 8(12).
3. Al-Bakri, J., Suleiman, A., Abdulla, F. and Ayad, J. (2011). Potential impact of climate change on rainfed agriculture of a semi-arid basin in Jordan. Physics and Chemistry of the Earth, Parts A/B/C, 36(5-6), pp.125-134.
4. Anim-Jnr, A.S., Sasu, P., Bosch, C., Mabiki, F.P., Frimpong, Y.O., Emmambux, M.N. and Greathead, H.M.R. (2023). Sustainable Small Ruminant Production in Low-and Middle-Income African Countries: Harnessing the Potential of Agroecology. Sustainability, 15(21), p.15326.
5. Asrat P, and Simane B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. Ecol Process 7(7), 1-23.
6. Awad, R., Mohamed-Brahmi, A., Titi, H., Jaouad, M. and Gasmi-Boubaker, A. (2023a). Assessing the small ruminant value chain in arid regions: A case study of the North-Eastern Badia Basalt Plateau in Jordan. J. Glob. Innov. Agric. Sci. 11(4): 549-560

7. Awad, R., Mohamed-Brahmi, A., Titi, H., Jaouad, M. and Gasmi-Boubaker, A. (2024). Enhancing the Small Ruminant Value Chain Using Swot Analysis in Mafraq Governorate, Jordan- Anbar Journal of Agricultural Sciences. 22 (2).
8. Awad, R., Titi, H., Mohamed-Brahmi, A., Jaouad, M. and Gasmi-Boubaker, A. (2023b). Small ruminant value chain in Al-Ruwaished district, Jordan. Regional Sustainability, 4(4), pp.416-424.
9. Banjoko, I.K., Ifabiyi, J.O., Lawal, S.W., Ahmed, S.A., Isiaka, M.A. and Komolafe, S.E. (2021). Small Ruminant Farmers' Perception of Climate Change in Moro Local Government Area, Kwara State, Nigeria. Nigeria Agricultural Journal, 52(2), pp.289-296.
10. Bashabsheh, A. Q., Alzboon, K. K., and Alshboul, Z. (2025). Spatial trends of extreme temperature events and climate change indicators in climate zones of Jordan. Journal of Arid Land, 17(11), 1542-1557.
11. Chauhan, S.S., Zhang, M., Osei-Amponsah, R., Clarke, I., Sejian, V., Warner, R. and Dunshea, F.R. (2023). Impact of heat stress on ruminant livestock production and meat quality, and strategies for amelioration. Animal Frontiers, 13(5), pp.60-68.
12. Chedid, M., Tourrand, J.F., Jaber, L.S. and Hamadeh, S.K. (2018). Farmers' perception to change and adaptation strategies of small ruminant systems in the West Bekaa of Lebanon. Small Ruminant Research, 167, pp.16-21.
13. Debela, N., Mohammed, C., Bridle, K., Corkrey, R. and McNeil, D. (2015). Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia. SpringerPlus, 4, pp.1-12.
14. Demirbük, M. (2021). An analysis on the perception of small ruminant breeders to climate change and the factors affecting adaptation: A case study of Karaman province. Journal of the Institute of Science and Technology, 11(1), pp.686-698.
15. El-Anis, I. and Poberezhskaya, M. (2023). Responding to Climate Change in Jordan: understanding institutional developments, political restrictions and economic opportunities. British Journal of Middle Eastern Studies, pp.1-19.
16. Godde, C.M., Mason-D'Croz, D., Mayberry, D.E., Thornton, P.K. and Herrero, M. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. Global food security, 28, p.100488.
17. Joy, A., Dunshea, F.R., Leury, B.J., Clarke, I.J., DiGiacomo, K. and Chauhan, S.S. (2020). Resilience of small ruminants to climate change and increased environmental temperature: A review. Animals, 10(5), p.867.
18. Katsarou, E.I. and Fthenakis, G.C. (2023). Relationship between Vaccine Application and Climate Factors in Sheep and Goat Farms in Greece. Vaccines, 11(4), p.797.
19. Khader, A. (2013). Preparing research and scientific theses from idea to conclusion. Faculty of Education, Al-Azhar University, Cairo (in Arabic)
20. Kimeli, P., Mwacalimba, K., Tiernan, R., Mijten, E., Miroshnychenko, T., and Poulsen Nautrup, B. (2025). Important diseases of small ruminants in sub-Saharan Africa: a review with a focus on current strategies for treatment and control in smallholder systems. Animals, 15(5), 706.
21. Lacetera, N., 2019. Impact of climate change on animal health and welfare. Animal Frontiers, 9(1), pp.26-31.
22. Lallo, C.H., Smalling, S., Facey, A. and Hughes, M. (2017). The impact of climate change on small ruminant performance in Caribbean communities. In Environmental Sustainability and Climate Change Adaptation Strategies (pp. 296-321). IGI Global.
23. Manjunathareddy, G.B., Sajjanar, B. and Sejian, V. (2017). Impact of Climate Change on Sheep Disease Occurrences and Its Management. Sheep Production Adapting to Climate Change, pp.197-207.
24. Nolan J, Harrison J, Boyer F. (2013). The interactive effects of excess reactive nitrogen and climate change on aquatic ecosystems and water resources of the United States. Biogeochemistry 114(1–3):71–92
25. Ocak Yetisgin, S., Önder, H., Şen, U., Piwczyński, D., Kolenda, M., Sitkowska, B. and Yucel, C. (2022). Farmers' Risk Perception on Climate Change: Transhumance vs. Semi-Intensive Sheep Production Systems in Türkiye. Animals, 12(15), p.1992.
26. Ogundeji, A.A., 2022. Adaptation to climate change and impact on smallholder farmers' food security in South Africa. Agriculture, 12(5), p.589.
27. Oroud, I.M. (2008). The impacts of climate change on water resources in Jordan. In Climatic changes and water resources in the Middle East and North Africa (pp. 109-123). Berlin, Heidelberg: Springer Berlin Heidelberg.
28. Osei-Amponsah, R., Chauhan, S.S., Leury, B.J., Cheng, L., Cullen, B., Clarke, I.J. and Dunshea, F.R. (2019). Genetic selection for thermotolerance in ruminants. Animals, 9(11), p.948.

29. Popoola, O.O., Monde, N. and Yusuf, S.F.G. (2019). Perception and adaptation responses to climate change: An assessment of smallholder livestock farmers in Amathole district Municipality, Eastern Cape Province. South African Journal of Agricultural Extension, 47(2), pp.46-57.
30. Sahoo, A. (2023). Small ruminants: supporting socio-economic livelihood. In: Sahoo, A. and Rahman H. DONKEY & NON-BOVINE MILK, ILRI-NRCC Publication, Bikaner, India. p.58.
31. Salahat, M. and M. Al-Qinna. (2015). Rainfall fluctuation for desertification and climate change: new aridity classification. Jordan Journal of Earth and Environmental Sciences. 7(1): 27-35
32. Serranito, B., Cavalazzi, M., Vidal, P., Taurisson-Mouret, D., Ciani, E., Bal, M., Rouvellac, E., Servin, B., Moreno-Romieux, C., Tosser-Klopp, G. and Hall, S.J. (2021). Local adaptations of Mediterranean sheep and goats through an integrative approach. Scientific Reports, 11(1), p.21363.
33. Tendonkeng, F., Arnaud, H.T.B., Noumbissi, M.N.B., Miegoue, E., Sawa, C., Essie, F.M.N., Mboko, A.V., Tovignon, G.Z., Nde, A.N., Tedonkeng, E.P. and Vargas-Bello-Pérez, E. (2021). Perceptions and Adaptation Strategies for Climate Change from Small Ruminant Farmers in North-West Cameroon. Tropical and Subtropical Agroecosystems, 25(1).
34. Trading Economics. 2024. Jordan average precipitation. https://tradingeconomics.com/jordan/precipitation
35. Tüfekci, H. and Çelik, H.T. (2021). Effects of climate change on sheep and goat breeding. Black Sea Journal of Agriculture, 4(4), pp.137-145.

مقالة أصيلة

القدرة على التكيف مع تغير المناخ في إنتاج المجترات الصغيرة في شمال الأردن: استراتيجيات للتكيف المستدام

رلا عوض * [١] ، عزيزة محمد-براهمي [٢]، حسام تيتي [٣]، محمد جواد [٤]، عزيزة قاسمي-بوبكر [١]

[١] قسم الإنتاج الحيواني، المعهد الوطني للز ارعة بتونس، جامعة قرطاج، تونس، ١٠٨٢، تونس

[٢] المدرسة العليا للز ارعة بالكاف، مختبر استدامة أنظمة الإنتاج في منطقة الشمال الغربي، جامعة جندوبة، الكاف، ٧١١٩، تونس.

[٣] قسم الإنتاج الحيواني، كلية الز ارعة، الجامعة الأردنية، عمان، ٩٩٩٠٤٥، الأردن.

[٤] معهد المناطق الجافة بمدنين، مختبر الاقتصاد والمجتمعات الريفية، مدنين، ٤١١٩، تونس.

الخلاصة يشكل تغير المناخ تحديًا متزايدًا لاستدامة قطاع تربية المجترات الصغيرة على الصعيد العالمي، مما يستدعي فهمًا معمقًا لتصورات المزارعين واستجاباتهم التكيفية من أجل تطوير تدخلات فعالة لبناء القدرة على الصمود. تهدف هذه الدراسة إلى اختبار فرضية مفادها أن إدراك المزارعين لتغير المناخ، إلى جانب ممارساتهم الإدارية وخصائصهم الديموغرافية، يؤثر بشكل مباشر في قدرتهم على التكيف واستدامة إنتاج المجترات الصغيرة في شمال الأردن. تم جمع البيانات من خلال استبيان شمل ٢٧٢ مزارعًا، بالإضافة إلى عقد مناقشات جماعية مركزة في أربع مناطق جغرافية مختلفة لتعزيز الفهم النوعي لآليات التكيف المعتمدة. أظهرت النتائج أن غالبية المزارعين أبلغوا عن ارتفاعات ملحوظة في درجات الحرارة وانخفاض في معدلات الهطول المطري وتدهور المراعي، على المستويين القصير والطويل الأمد. وعلى الرغم من هذه المؤشرات، فإن ٥٥٪ فقط من المستجيبين أعربوا عن قلقهم تجاه تغير المناخ، في حين لم يقم أكثر من ٧٠٪ بأي تعديلات فعلية لمواجهة هذه التغيرات، على الرغم من بدء البعض في تنفيذ تدابير تخفيفية. أظهرت الدراسة أيضًا أن هناك تفضيلًا ملحوظًا للسلالات المحلية نظرًا لقدرتها التكيفية العالية مع الظروف المناخية المحلية، كما لوحظت تعديلات في أنماط الرعي وإدارة التغذية استجابة للظروف المتغيرة. تشير النتائج إلى أن غالبية المزارعين أبدوا استعدادًا لتبني ممارسات جديدة في التربية، في حين أعربت نسبة غير ضئيلة عن إمكانية التخلي عن هذا النشاط في حال تفاقمت تأثيرات تغير المناخ. تؤكد هذه النتائج الحاجة إلى تعزيز الوعي وتوفير الدعم التقني للمزارعين بما يضمن تبني ممارسات زراعية مستدامة تعزز من قدرتهم التكيفية في ظل سيناريوهات مناخية متغيرة.

كلمات مفتاحية: المجترات الصغيرة، تغير المناخ، المرونة، الإدارة المستدامة، شمال الأردن

***المراسلة الى:** رلا عوض، قسم الإنتاج الحيواني، المعهد الوطني للزراعة بتونس، جامعة قرطاج، تونس، ١٠٨٢، تونس.

البريد الالكتروني : rula.a.awad@gamil.com :