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Sheep Farming for Resilient Dryland Livelihoods – A Review

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Abstract
Sheep farming plays a pivotal role in enhancing the resilience of dryland communities by providing multifunctional benefits such as meat, wool, milk, and manure, while serving as mobile financial assets during economic and climatic shocks. This review synthesizes current knowledge on the strategic importance of sheep-based systems in drought-prone regions, emphasizing their adaptability, low input requirements, and integration into traditional and modern farming practices. The scope covers economic viability, nutritional security, gender empowerment, market dynamics, environmental sustainability, and technological innovations. Evidence from diverse geographies highlights how sheep contribute to household income, food access, and ecological balance, particularly in resource-constrained settings. The review also explores challenges such as disease, feed scarcity, and limited institutional support, proposing solutions through policy frameworks, climate-resilient breeds, and inclusive extension services. By integrating indigenous knowledge with scientific advancements, sheep farming emerges as a cornerstone of sustainable development in drylands. The findings underscore the need for targeted interventions, infrastructure development, and participatory approaches to unlock the full potential of sheep-based livelihoods. This comprehensive analysis offers insights for researchers, policymakers, and practitioners aiming to strengthen climate adaptation and socio-economic resilience in vulnerable agro-ecosystems.
Keywords: Sheep farming, Dryland resilience, Climate adaptation, Livelihood security, Sustainable agriculture

1. INTRODUCTION

Dryland farming systems across the globe face mounting challenges from climate variability, water scarcity, and economic instability, threatening rural livelihoods and food security. These regions, marked by low rainfall and poor soil fertility, demand resilient agricultural strategies that can sustain income and adapt to environmental stress (Turner et al., 2014). As crop reliability declines, livestock—particularly sheep—have emerged as vital components of climate-resilient farming due to their adaptability, minimal input requirements, and efficient use of marginal grazing lands (Blache et al., 2016; Awad et al., 2023).

Sheep act as "biological processors," converting low-quality vegetation and agro-residues into valuable products such as meat, milk, wool, and manure. Their mobility and financial utility also support household liquidity during economic shocks, enhancing resilience (Kosgey et al., 2004). Figure 1 illustrates this multifunctionality, showing how low-cost inputs—like forage, water, land, and labor—are transformed into high-value outputs including wool, meat, offspring, manure, and cultural capital. By efficiently utilizing native grasslands, sheep contribute to both food security and ecological sustainability in drought-prone regions.

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This review explores the strategic role of sheep-based systems in strengthening financial resilience, promoting climate adaptation, and supporting inclusive development, with attention to policy frameworks, gender dynamics, and institutional support.

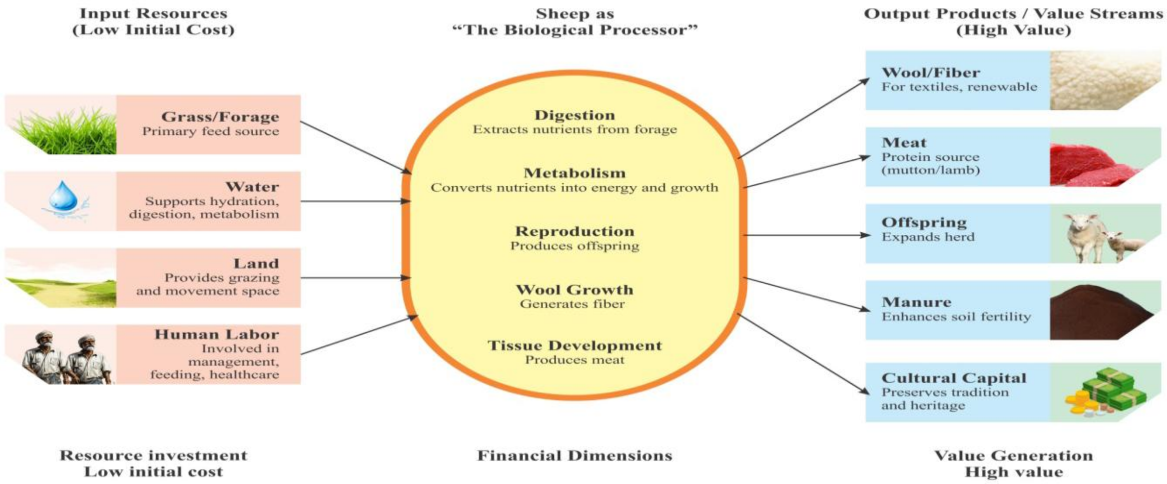

Figure 1. Sheep as Biological Processors: Turning Inputs into Valuable Farm Products

2. SHEEP AS MOBILE FINANCIAL ASSETS

Sheep serve as multifunctional and mobile financial assets in rural and pastoral economies, especially in dryland and low-resource settings. They provide both tangible outputs—such as meat, wool, manure, and skins—and intangible benefits, including their role as financial instruments and insurance buffers (Kosgey et al., 2004). Their portability, reproductive efficiency, and adaptability make them particularly valuable to asset-poor households. In rainfed agricultural systems, where crop yields are vulnerable to climatic variability, sheep offer liquidity through quick asset conversion and act as inflation-resilient stores of value (Naess & Bardsen, 2015; Zaremba et al., 2021). Strategic management of reproductive traits, such as fecundity and lambing frequency—especially in prolific breeds like Ouled Djellal—enhances their role as self-sustaining assets (Zidane et al., 2021). In South Africa's Free State, pure breeding increased weaning rates by 5.6%, while inbreeding reduced them by 11.3%. Training, rotational grazing, and herding support further improved flock productivity and health (Strauss et al., 2024). Figure 2 illustrates how sheep enhance the resilience of dryland farming systems by supporting household income, food access, and risk mitigation. As adaptive assets in diversified livestock portfolios, sheep buffer against climatic and economic shocks, improve dietary diversity, and support income smoothing strategies (Ngigi et al., 2021).

Figure 2. Beneficial Effects of Sheep on Dryland Communities

3. ECONOMIC BENEFITS FOR DRYLAND FARMERS

Sheep farming in dryland regions offers significant economic advantages due to low input requirements and efficient use of native grasslands (Tzanidakis et al., 2017). These systems are environmentally friendly, emitting fewer greenhouse gases than intensive livestock operations (Ledgard et al., 2011). Primary income comes from meat, with wool providing secondary revenue—such as a benefit-cost ratio of 1.38 reported in Rajasthan (Naikoti et al., 2024). Additional outputs like milk and nutrient-rich manure contribute to soil fertility (Chadda et al., 2025).

Profitability is further enhanced in agrivoltaic systems, with Return on Investment (ROI) ranging from 16% to 43% (Gasch et al., 2025), and mid-season lambing yielding better financial returns than early lambing (Bohan et al., 2016). Long-term capital appreciation has raised historical returns from 0.6% to 5.0% (Jackson & Valle, 2015). In Jordan's Mafraq Governorate, farms generate an average of $60.91 per animal annually, supported by low debt-to-asset ratios (Al-Barakeh et al., 2024).

Compared to cattle, sheep are more resilient in arid zones due to lower water needs and superior forage adaptability (Nair et al., 2021). While goats offer greater drought tolerance, mixed herding provides complementary benefits (Zenda & Malan, 2021). Large-scale operations benefit from economies of scale and innovations in breeding and feeding (Toro-Mujica et al., 2015). Improved practices, including the use of nutrient-rich feeds like cactus cladodes and legumes, enhance performance and reduce methane emissions across both humid and semi-arid regions (Ibidhi & Ben Salem, 2018; Mwangi et al., 2024).

4. ROLE IN HOUSEHOLD RESILIENCE AND RISK MANAGEMENT

Sheep function as liquid assets that support household stability during crises, especially in regions lacking formal financial services (Bahta, 2020; Collishaw et al., 2023). Their integration with land, savings, and social networks enhances coping capacity and enables quick responses to health, education, and food needs (Ngigi et al., 2021). During droughts, farmers adopt adaptive strategies such as selling livestock, diversifying income, using drought-tolerant breeds, and implementing water management practices (Bahta, 2022; Kumar et al., 2025).

Livestock initiatives also empower women by improving decision-making and food security, though gender barriers remain (Farnworth et al., 2023; Ogolla et al., 2022). Pastoralists employ resourceful practices like grass harvesting, crop residue use, and woody plant supplementation to manage seasonal variability (Ouedraogo et al., 2021), while mobility strategies such as transhumance offer further resilience (Turner et al., 2014). Infrastructure improvements like water retention structures in Niger enhance soil moisture and productivity (Mishra et al., 2023), and tools such as Feed Balance Sheets help monitor feed availability and support informed decision-making (Mottet & Assouma, 2024).

5. NUTRITIONAL SECURITY THROUGH SHEEP-BASED LIVELIHOODS

In arid regions where conventional agriculture is limited by poor soil and water scarcity, sheep-based livelihoods offer a reliable path to nutritional security. Sheep efficiently convert low-quality vegetation into high-value protein, making them ideal for resource-constrained environments (Blache et al., 2016). Their meat is rich in calcium, beneficial fats, and bioactive compounds like CLA, which support bone and heart health in nutritionally vulnerable populations (Flis & Molik, 2021). Sheep milk, with higher protein, fat, and mineral content than cow or goat milk, serves as a valuable functional food (de la Fuente et al., 2013).

In Algeria's M'Sila region, farmers prioritize traits like meat quality, rapid growth, and fattening capacity, which contribute to both household nutrition and income (Aouina et al., 2025). Feeding practices are adapted to seasonal availability, using pastures, crop residues, and green forage like barley. Although only a minority of farmers use supplements, balanced nutrition improves reproduction and herd health. Techniques such as flushing and estrus synchronization enhance lamb survival and productivity. Economically, sheep farming yields an average net income of €265 per animal, supporting food access in semi-arid zones (Aouina et al., 2025).

Beyond direct nutrition, sheep contribute to soil fertility through manure, reinforcing livestock–crop integration (Battheu-Noirfalise et al., 2024). They also serve as cultural and economic assets, supporting food security through income generation, social capital, and resilience to climate shocks (Alulu et al., 2024). Their integration into mixed farming systems maximizes productivity from limited natural resources, making them essential for climate-resilient livelihoods (Pankaj et al., 2020)

6. MARKET SYSTEMS AND VALUE CHAINS

In dryland regions, livestock market systems form a dynamic socio-economic network essential for local economies and food security. These systems connect producers, intermediaries, and consumers, adapting to environmental changes and population pressures (Turner et al., 2014). Sheep contribute significantly by providing protein, income, and manure, while also acting as buffers against climate shocks and supporting wealth accumulation (Oosting et al., 2025).

Urban and periurban feed markets in the West African Sahel help mitigate seasonal shortages, though feed prices often fluctuate and may not reflect nutritional quality (Ayantunde et al., 2022). Traditional trekking methods continue to operate alongside modern transport systems, offering complementary logistics for livestock movement (Corniaux et al., 2012). In Turkey, seasonal feed costs and currency fluctuations impact income stability for sheep producers, though similar data is limited for other regions like Brazil and Tanzania (Urak et al., 2022).

Despite declining wool prices, value addition strategies remain important for sustaining rural incomes and environmental goals (Ozek, 2023). Expanding wool markets requires innovation in processing, marketing, and infrastructure (Chadda et al., 2025). However, remote farmers often face barriers such as poor infrastructure and limited policy support, restricting access to modern systems (Nori & Scoones, 2023). The growing use of digital tools—like smartphones and online platforms—offers new opportunities for market access, though challenges such as weak signals, language barriers, and low digital literacy persist (Oki & Agbeyangi, 2024). Addressing these gaps is crucial for building resilient and inclusive market systems in dryland livestock economies.

7. ENVIRONMENTAL SUSTAINABILITY AND CLIMATE ADAPTATION

Sustainable sheep farming in drought-prone areas relies on adaptive grazing, climate-resilient breeds, and integrated land use strategies. Techniques such as rotational and Adaptive Multi-Paddock (AMP) grazing enhance vegetation recovery, livestock performance, and soil carbon storage. Short-term grazing exclusion during favorable rainfall periods also improves plant diversity and soil nutrients (Ru et al., 2024). When managed with site-specific stocking densities, sheep grazing supports biodiversity and ecosystem protection (Ross et al., 2016).

Indigenous breeds like Phan Rang, Hungarian Tsigai, and Saudi Najdi exhibit strong heat tolerance and genetic resilience, aided by physical traits and stress-responsive genes (Nxumalo et al., 2024). Livestock mobility, including transhumance, helps manage seasonal forage availability and mitigate drought impacts, though land-use changes increasingly constrain these practices (Pardo et al., 2024).

Pastoral system resilience is strengthened through herd diversification, improved water and feed management, and supplementary income sources (Dong et al., 2023). Integrated crop-livestock systems with sheep enhance soil health, reduce reliance on synthetic inputs, and support ecosystem services, despite ongoing greenhouse gas challenges (Swanepoel & Smit, 2025). In Australia, improved grazing practices—such as rest periods and adjusted stocking rates—have led to increased ground cover and better ecological outcomes (McDonald et al., 2024).

8. TECHNOLOGICAL INNOVATIONS IN SHEEP PRODUCTION

Enhancing resilience in dryland sheep farming requires innovations in breeding, health, and feeding. Climate-resilient breeds such as Bonga and Menz, along with genomic selection in Egyptian sheep, improve thermotolerance and adaptability (Tesema et al., 2025; Aboul-Naga et al., 2022). Disease control benefits from One Health approaches and mobile technologies, though adoption is influenced by socio-economic factors (Lane et al., 2025; Erdem & Ağır, 2024).

Feeding strategies like creep feeding and prophylactic care boost productivity (Kumar et al., 2021). Indigenous knowledge systems (IKS), including ethnoveterinary practices using medicinal plants, offer cost-effective solutions in underserved areas (Phaahla et al., 2025). Traditional mobility and diversified feeding help farmers adapt to climate variability, but these practices risk erosion without formal recognition and validation (Napogbong et al., 2021; Nwafor & Nwafor, 2022). Community-based documentation and participatory approaches are essential for integrating IKS into inclusive, climate-resilient sheep production systems (Negi et al., 2025).

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9. CHALLENGES AND CONSTRAINTS IN SHEEP-BASED LIVELIHOOD SYSTEMS

Sheep farming in arid regions faces multiple challenges, including disease outbreaks, feed scarcity, and climate variability. Drought accelerates pasture degradation (Lal, 2023), while diseases like fasciolosis and Mycoplasma ovipneumoniae require integrated control strategies (Tesfay et al., 2021). Innovations such as microalgae-based feed offer protein-rich alternatives, but land policies and climate change continue to restrict pasture access, prompting the need for adaptive strategies (Lafuente-Rincon et al., 2024; Zeng et al., 2024).

Climate shifts impact reproduction and animal welfare, and while farmers respond with improved feed management and heat-tolerant breeds, limited access to forecasts and extension services hampers these efforts (Ramana, 2022; Bontsa et al., 2024). Smallholders also struggle with inadequate veterinary services and financial constraints (Haakuria et al., 2020). In regions like Mali and Ethiopia, climate variability and weak market systems push farmers toward subsistence-level production (Abay & Jensen, 2020). Conversely, in China, trader competition and policy incentives have improved market access (Li et al., 2025). Building resilience in sheep-based systems requires integrated support across animal health, resource management, and climate adaptation to ensure sustainable livelihoods.

10. POLICY FRAMEWORK AND INSTITUTIONAL SUPPORT

Sheep farmers in dryland regions require targeted support through credit, insurance, and financial services to strengthen their livelihoods. However, challenges such as livestock undervaluation, complex claims processes, and low awareness limit the effectiveness of insurance schemes (Adams et al., 2021). Access to loans is shaped by factors like education, financial literacy, and proximity to institutions, with demographic variables further influencing engagement (Asfaw et al., 2023; Shivakumara et al., 2020). Improved credit access enables investment in better breeds and practices, benefiting women and marginalized groups (van Asseldonk et al., 2024; Koomson & Ahmad, 2024).

Extension services and cooperatives play a vital role in promoting sustainability and market access, though funding limitations persist (Mani et al., 2025; Ma et al., 2023). Participatory research fosters innovation, while infrastructure, training, and governance reforms are essential for equitable development (Moojen et al., 2024; Nori & Scoones, 2023). Integrated models like Morocco's agro-silvo-pastoral system demonstrate sustainable land use (Boughalmi et al., 2015), and resilient breeds such as Jordan's Awassi sheep highlight the success of traditional systems (Talafha & Ababneh, 2011).

Figure 3 illustrates how sheep ownership empowers women by enhancing income, decision-making, and social status. Inclusive approaches - such as livestock schools and gender-sensitive services - can drive transformative change in dryland livestock economies.

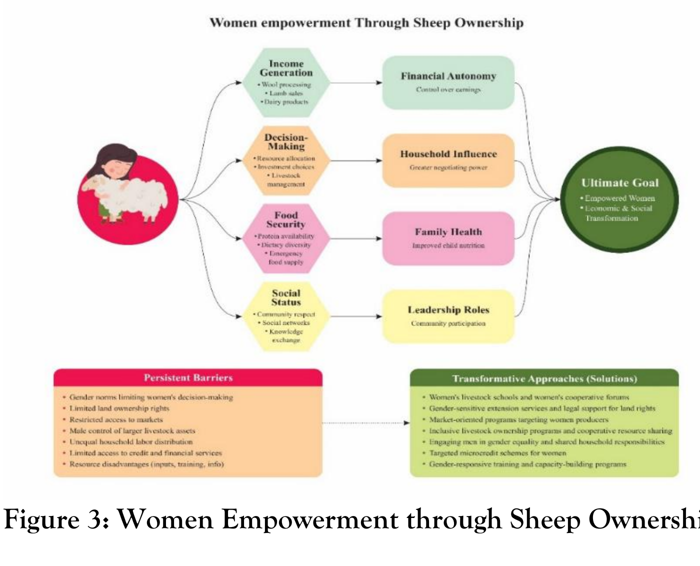

Figure 3: Women Empowerment through Sheep Ownership

11. CONCLUSION

Sheep-based livelihood systems are essential for dryland regions, offering economic flexibility, ecological sustainability, and community resilience. Their dual role as mobile financial assets and nutrient-rich food sources supports sustainable development in resource-constrained environments. Success depends on adaptive management, integration of traditional and scientific knowledge, and localized decision-making. Institutional support—particularly in animal health, resource access, and market connectivity—is critical. As climate conditions and market dynamics evolve, innovation and continuous adaptation must be prioritized. This review highlights the transformative potential of sheep-based systems in addressing persistent challenges and guiding inclusive, climate-resilient development in dryland areas.

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