

Sustainable Management and Feeding Practices in Sheep and Goat Production in Norte de Santander, Colombia

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Abstract: Objective: To describe and assess management and feeding practices in sheep and goat production systems in Norte de Santander, Colombia, in order to identify improvement opportunities towards productive sustainability. Methodology: A descriptive cross-sectional study was conducted using a structured 22-item Likert-scale questionnaire applied to 50 sheep and goat producers in the region, selected through non-probabilistic convenience sampling during a technical field visit. Data were analyzed using descriptive statistics, including absolute and relative frequencies, measures of central tendency, and dispersion. Results: A total of 86% of producers (n = 43) acknowledged the importance of meat and dairy product quality; 82% (n = 41) expressed the need for training in livestock marketing; and the majority considered the adoption of sustainable production systems a priority. Deficiencies in technology transfer, sanitary management, and diversification of the herd's feed base were identified. Conclusions: Findings highlight the urgency of incorporating good livestock practices grounded in regenerative agriculture, continuous producer training, and articulation with sustainable value chains to strengthen the competitiveness of the sheep and goat sector in the region.

Keywords: Animal welfare, livestock sustainability, sheep production, goat production, good livestock practices, food safety, Norte de Santander

1. Introduction

Sheep and goat production constitutes a strategic component of food security and the socioeconomic development of rural communities in developing countries (Caroprese et al., 2015; Silva et al., 2022). Globally, small ruminant production systems face significant challenges associated with productive efficiency, commercial competitiveness, and environmental sustainability—factors that demand the incorporation of technological innovations and evidence-based practices (Al-Barakeh et al., 2024; Mahgoub & Lu, 2025).

In Colombia, sheep and goat production is characterized by limited technology transfer, the predominance of traditional production systems managed by smallholder families oriented toward local consumption, and a low contribution to the agricultural gross domestic product (Mestra et al., 2020). These systems exhibit excessive dependence on commercial concentrates to the detriment of local forage resources, which increases production costs and reduces the economic resilience of producers (Vega et al., 2014).

Technological management and the optimization of productive processes are essential to meet the growing demand for animal-origin protein products and to satisfy the quality and competitiveness standards required by emerging markets (Vega, 2017). In this context, good livestock practices enable the regulation and standardization of



effective production by articulating criteria of animal welfare, environmental sustainability, and economic profitability (FAO, 2009).

A modernized agricultural sector requires the incorporation of innovative production structures adapted to the conditions of global trade, which entails profound transformations in rural organization that respond to consumer demands in an environment of increasing complexity (Vega et al., 2014). Specifically, the Norte de Santander region presents favorable agroecological conditions for small ruminant production; however, a knowledge gap persists regarding the management and feeding practices implemented by local producers and their degree of alignment with sustainability principles.

Countries striving to maintain adequate and accessible food security for their populations—at the physical, social, and economic levels—require the production of animal-origin protein foods based on the development of competitive livestock enterprises. The rearing of sheep and goats maintained on nitrogen-rich plant material as a priority component of their diet is essential for microbial protein synthesis and the overall sustainability of these production systems (Rodríguez, 2013).

The present study aims to describe and assess management and feeding practices in sheep and goat production systems in Norte de Santander, with the purpose of identifying improvement opportunities oriented toward strengthening the productive sustainability of the sector.

2. Theoretical Framework

2.1. Sustainable feeding strategies in the livestock sector

Sustainable feeding practices in ruminant production are grounded in optimizing the use of local forage resources and reducing dependence on external inputs. Nutrition based on ecological production includes the incorporation of forages such as sorghum, alfalfa hay, and corn silage, supplemented with non-protein nitrogen sources free of synthetic chemical agents (Bejarano et al., 2021).

The use of feed additives aimed at improving nutrient absorption and reducing greenhouse gas emissions—particularly methane—represents a dual-benefit strategy: increasing animal productivity while strengthening the environmental sustainability profile of the system (Petre & Sarvaas, 2025). Additionally, *in vitro* fermentation of agricultural by-products such as dried oats, corn leaves, and vegetable residues yields substrates for animal feeding and simultaneously produces biogas as an alternative bioenergy source (Alcamaraz et al., 2023).

Sustainable animal feeding integrates techniques aimed at maintaining herd health and welfare through the efficient use of natural resources, establishing a balance between livestock production and environmental conservation. This approach is founded on balanced and nutritious diets, grounded in the principles of regenerative agriculture and enhanced through advanced technology, including the promotion of genetic diversity (iBridge Capital, 2024; Mahgoub & Lu, 2025).

2.2. Sustainable pasture management

Strategic pasture management constitutes a fundamental pillar for herd nutrition and the sustainability of the pastoral ecosystem. Planned paddock rotation, aimed at maintaining the vigor of forage plants with minimal herbicide use, promotes both livestock productivity and environmental protection (Osechas & Becerra, 2009).

From the perspective of General Systems Theory (von Bertalanffy, 1968), the livestock sector can be analyzed as an open and complex system, composed of biological, technical, and managerial dimensions, where the inputs and outputs of the productive environment are mediated by market dynamics, climatic factors, and public policies (Siffredi, 2009). This systemic approach enables the assessment and monitoring of the ecological, economic, and productive factors that determine decision-making at the territorial level.

Regenerative livestock farming, centered on the integrated management of cattle and grazing lands, seeks to restore natural feeding patterns through planned herd rotation across different grazing zones during brief periods,

allowing for pasture rest and recovery under constant supervision to prevent overgrazing (Bravo et al., 2024). Grazing control, water flow management, and soil fertility monitoring are essential components of this strategy (EOS Data Analytics, 2025).

2.3. Sanitary management and animal welfare

Animal welfare encompasses interrelated ethical, economic, and sanitary dimensions whose adequate management is determinant for the quality of livestock products and food safety. The implementation of practices that contribute to alleviating pain, preventing diseases, and improving herd living conditions is indispensable for productivity based on ecological sustainability (Díaz, 2012).

Deficiencies in animal handling during loading and transport generate significant losses through seizures and injuries, adverse metabolic changes, stress, and trauma that deteriorate meat quality and shorten the animal's useful life. The application of humane handling protocols, preventive sanitary care, and timely disease attention constitute both ethical and productive priorities (Tafur & Acosta, 2006; Brennecke et al., 2020).

Comprehensive sanitary management encompasses facility cleanliness, pathogen control, proper manure and waste management, the provision of balanced nutrition, and stress reduction, complemented by professional veterinary advisory services and the implementation of structured sanitary plans (FAO, 2009; Ceballo, 2025).

3. Methodology

3.1. Research design

A descriptive cross-sectional design with a quantitative approach was implemented, aimed at characterizing management and feeding practices in sheep and goat production systems in Norte de Santander, Colombia.

3.2. Population and sample

The population comprised sheep and goat producers in Norte de Santander engaged in livestock activities. The non-probabilistic convenience sample included 50 producers who participated in a technical field visit conducted in the region. Inclusion criteria were: (a) being an active sheep or goat producer, (b) having a minimum of one year of experience in the activity, and (c) providing informed consent to participate in the study.

3.3. Data collection instrument

A structured questionnaire with 22 items organized into three dimensions was designed: (i) product quality and good manufacturing practices, (ii) livestock training and marketing, and (iii) sustainability of production systems. Responses were recorded on a five-point Likert scale, where 1 = Strongly Disagree and 5 = Strongly Agree. The content validity of the instrument was assessed through expert judgment, and its reliability was estimated using Cronbach's alpha coefficient.

3.4. Procedure and data analysis

Data collection was conducted in situ during the technical field visit, in a participatory learning environment where producers accessed practical experiences and exchanged knowledge. Data were processed using descriptive statistics, employing absolute and relative frequency tables, as well as measures of central tendency and dispersion, with the support of SPSS v. 26 statistical software.

4. Results

The results are presented below, organized according to the three dimensions assessed by the research instrument.

4.1. Product quality and current market excellence

Table 1 presents the indicators related to producers' perceptions of the quality of meat and dairy products in the region's production systems.

Table 1. Producers' perceptions of product quality and current markets (n = 50)

Indicator	SA	A	NAD	D	SD
Importance of meat and dairy product quality	43 (86%)	5 (10%)	2 (4%)	0 (0%)	0 (0%)
Implementation of HACCP protocols in the production chain	38 (76%)	8 (16%)	3 (6%)	1 (2%)	0 (0%)
Quality certification as a competitiveness factor	40 (80%)	7 (14%)	2 (4%)	1 (2%)	0 (0%)

Note. SA = Strongly Agree; A = Agree; NAD = Neither Agree nor Disagree; D = Disagree; SD = Strongly Disagree. Source: authors' own elaboration.

The indicator with the highest endorsement was the recognition of the importance of meat and dairy product quality, with 86% (n = 43) of producers expressing strong agreement. These results are consistent with FAO (2011) guidelines on good manufacturing practices, which underscore the need to implement Hazard Analysis and Critical Control Points (HACCP) protocols across production, processing, and marketing stages.

4.2. Training and success in modern livestock production

Table 2 presents the results pertaining to producers' perceptions of the need for training in livestock marketing and business management.

Table 2. Perceptions of livestock training and marketing (n = 50)

Indicator	SA	A	NAD	D	SD
Need for training in livestock marketing	41 (82%)	6 (12%)	2 (4%)	1 (2%)	0 (0%)
Access to continuous technical training	39 (78%)	7 (14%)	3 (6%)	1 (2%)	0 (0%)
Linkage with regional value chains	36 (72%)	9 (18%)	4 (8%)	1 (2%)	0 (0%)

Note. SA = Strongly Agree; A = Agree; NAD = Neither Agree nor Disagree; D = Disagree; SD = Strongly Disagree. Source: authors' own elaboration.

A total of 82% (n = 41) of respondents expressed strong agreement with the need for training in livestock product marketing. This finding is consistent with Mata (2020), who identified a limited market vision among agricultural producers, particularly regarding demand requirements and integration into sustainable value chains that promote the rural economy.

4.3. Sustainable systems in livestock production

Table 3 presents the results concerning perceptions of the sustainability of livestock production systems.

Table 3. Perceptions of production system sustainability (n = 50)

Indicator	SA	A	NAD	D	SD
Future need for sustainability in production systems	44 (88%)	4 (8%)	1 (2%)	1 (2%)	0 (0%)
Adoption of regenerative livestock practices	37 (74%)	8 (16%)	4 (8%)	1 (2%)	0 (0%)
Balance between productive efficiency and environmental responsibility	42 (84%)	5 (10%)	2 (4%)	1 (2%)	0 (0%)

Note. SA = Strongly Agree; A = Agree; NAD = Neither Agree nor Disagree; D = Disagree; SD = Strongly Disagree. Source: authors' own elaboration.

The sustainability of production systems was the indicator with the highest consensus: 88% (n = 44) of producers considered it a future priority. This result is congruent with Molina and Sánchez (2017), who argue that the Colombian livestock system requires a viable economy with environmental responsibility, reassessing the relationship between efficiency and natural resource management.

5. Discussion

The results of the present study reveal a favorable perception among sheep and goat producers in Norte de Santander toward the incorporation of sustainable practices, continuous training, and productive quality improvement. Nevertheless, this perception contrasts with the structural limitations that characterize the sector in the region.

The high percentage of producers (86%) who recognize the importance of meat and dairy product quality is a positive indicator, but it must be interpreted in light of the existing gap between declarative knowledge and the effective implementation of quality protocols. Previous studies in similar contexts have documented that sheep production in Colombia is characterized by limited technology transfer and the predominance of traditional systems that hinder the adoption of international standards (Mestra et al., 2020; Vega, 2017).

The demand for marketing training (82%) reflects a critical need within the sector. As Mata (2020) and Vega et al. (2014) have noted, the competitive insertion of smallholder producers into markets requires not only technical training but also the development of managerial and commercial capacities that enable value addition to products and access to more profitable distribution channels.

The majority consensus on the need for sustainability (88%) is consistent with the global trend toward production systems that balance economic profitability with environmental responsibility (Caroprese et al., 2015; Silva et al., 2022; Al-Barakeh et al., 2024). The implementation of regenerative livestock strategies, such as planned pasture rotation and diversification of the herd's feed base, constitutes a viable pathway to achieve this objective in the regional context (Bravo et al., 2024).

However, the transition toward sustainable models faces significant barriers, including productive fragmentation, limited access to financing, and weak institutional coordination. Jaimes et al. (2022), in a study on the sustainability of sheep production in the Santander páramo ecosystem, identified similar critical points related to feed supplements, state support, and access to veterinary services, which reinforces the need for differentiated public policies for the sector.

It is pertinent to note the limitations of the present study, which include the reduced sample size (n = 50), non-probabilistic sampling, and the self-reported nature of the data, all of which limit the generalizability of the results. Future research should expand the sample, incorporate longitudinal designs, and complement perceptual data with objective measurements of productivity and sustainability.

6. Conclusions

The study demonstrates that sheep and goat producers in Norte de Santander recognize the importance of productive quality, marketing training, and sustainability as pillars of sectoral development. However, significant gaps persist between favorable perceptions and the effective implementation of good livestock practices.

The findings indicate the need to: (a) progressively incorporate good manufacturing practices and sanitary quality protocols into local production chains; (b) design continuous training programs aimed at strengthening producers' technical and commercial capacities; (c) promote the adoption of regenerative livestock models that optimize the use of local forage resources and reduce dependence on external inputs; and (d) articulate public policies that facilitate the transition toward sustainable production systems, with emphasis on access to veterinary services, financing, and technical assistance.

These findings contribute to the body of knowledge on small ruminant production systems in Colombia and provide elements for the formulation of intervention strategies aimed at strengthening the competitiveness and sustainability of the sheep and goat sector in the region.

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INSTITUTIONAL ETHICS COMMITTEE STATEMENT

Not applicable.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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