

## **Agrostology Approaches to Pasture Management and Feed Calculation for Sheep: A PRISMA Review**

**Laeli Fitrah**

Faculty of pharmacy, health, and science, Muhammadiyah University of Kuningan, West Java, Indonesia

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**Corresponding author\*:**

[Laelifitrah@umkuningan.ac.id](mailto:Laelifitrah@umkuningan.ac.id)

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**Abstract:** Sheep farming plays a crucial role in smallholder livestock systems across tropical regions, including Indonesia, where forage availability and feeding efficiency remain major challenges. Agrostology, as the study of pastures and forage resources, provides essential insights into sustainable feed planning and pasture management strategies. This study conducts a Systematic Literature Review (SLR) using the PRISMA 2020 guidelines to synthesize recent evidence (2020–2025) on forage-based feed calculation and pasture management for sheep. A total of 19 peer-reviewed articles were identified from open-access databases, with inclusion criteria focusing on sheep nutrition, forage productivity, and pasture utilization, supplemented with comparative studies on cattle for broader context. Findings reveal that integrating nutrient requirement models (e.g., NRC, region-specific standards) with locally adapted forage species significantly improves sheep productivity while reducing feeding costs. Moreover, rotational grazing, silvopastoral systems, and mixed forage strategies enhance pasture resilience, nutritive value, and animal performance in tropical environments. Comparative evidence from cattle-based systems further emphasizes the relevance of forage diversity and strategic supplementation in sustaining productivity under seasonal feed fluctuations. Despite these advances, gaps remain in the adoption of participatory feed planning tools, context-specific pasture evaluation, and digital-based feed calculation models for smallholders. This review highlights the importance of combining agrostological approaches with community-based feed management to improve the sustainability of sheep production. The insights are particularly relevant for smallholder systems in regions such as Kuningan, West Java, where forage potential exists but requires structured feed planning.

**Keywords:** Agrostology; Sheep farming; Pasture management; Feed calculation; PRISMA review; Tropical smallholder systems

### **INTRODUCTION**

Sheep production plays an essential role in smallholder livestock systems across tropical regions, providing meat, income, and socio-cultural value for rural communities [1]. In Indonesia, sheep farming is concentrated in smallholder settings where livestock are often maintained under traditional systems with limited access to formulated feed resources [2]. Feed availability, particularly forage, is the most significant constraint, as seasonal fluctuations in pasture growth often result in underfeeding during dry periods and surplus during rainy seasons [3]. Addressing this issue requires structured feed planning and efficient pasture management based on agrostological principles.

Agrostology, the study of grasses and forage plants, provides a scientific basis for evaluating pasture productivity, nutritional quality, and sustainability under various ecological conditions [4]. Several studies have demonstrated that improved pasture species, such as *Brachiaria* cultivars, exhibit higher dry matter accumulation and crude protein content under tropical and semi-arid conditions [5]. Similarly, forage diversity in

silvopastoral systems has been linked to enhanced nutritive value and resilience of pasture ecosystems, offering sustainable options for smallholder sheep production [6]. However, despite these advances, smallholder farmers often lack the tools and knowledge to calculate nutrient requirements and match them with available forage resources [7].

Feed calculation models, such as those derived from the National Research Council (NRC) and adapted for tropical environments, are crucial in ensuring balanced diets for small ruminants [8]. Studies on fat-tailed sheep fed with Odot grass have shown that nutrient intake directly influences both productivity and environmental impacts, including methane emission [9]. Research also indicates that supplementation strategies, such as the inclusion of *Calliandra calothyrsus* or cactus pear-based silage, improve nutrient intake efficiency and reduce feeding costs in sheep production [1][10]. Integrating such strategies with forage availability assessments can improve both animal performance and resource use efficiency.

Pasture management practices further determine the sustainability of forage-based sheep farming. Rotational grazing, for instance, has been shown to improve forage regrowth, maintain nutritive value, and enhance milk production in dairy cattle, providing valuable insights for small ruminant systems [11]. Comparative studies between silvopastoral systems and monoculture pastures in sheep production demonstrated higher forage production and better animal ingestive behavior under diversified systems [3]. These findings highlight the importance of agrostological approaches that consider not only forage quantity but also nutritional composition and ecological interactions.

Evidence from cattle-based systems reinforces these lessons. Forage allowance and supplementation strategies for beef cattle in tropical pastures highlight the importance of balancing feed intake with seasonal forage fluctuations [12]. Similarly, agroforestry and silvopastoral systems in cattle production have proven effective in improving biodiversity, soil fertility, and long-term forage productivity [6][13][14]. Integrating these insights into sheep-based systems in tropical smallholder contexts can help design more sustainable models of pasture utilization and feed planning.

Despite these advances, significant research gaps remain. First, most feed calculation studies have focused on experimental or station-based trials, with limited application in smallholder, community-driven systems [2][7]. Second, there is a lack of participatory tools to assist farmers in calculating and adjusting feeding plans according to locally available forage resources [15]. Third, digital innovations, such as mobile applications and spreadsheet-based feed calculators, though increasingly applied in cattle systems, are rarely adapted for sheep in tropical smallholder settings [14].

Therefore, a systematic review is needed to synthesize current knowledge on pasture utilization and feed calculation for sheep, with attention to their applicability in smallholder contexts. By applying PRISMA 2020 guidelines, this review aims to identify, evaluate, and summarize existing studies (2020–2025) on agrostology-based feed management. The scope covers both sheep-specific research and comparative insights from cattle systems to provide a broader agrostological framework. Ultimately, this study intends to inform sustainable feed management strategies that are contextually relevant for regions such as Kuningan, West Java, where forage potential exists but requires structured feed planning and management at the community level.

## **METHODS**

This study applied a Systematic Literature Review (SLR) approach, following the PRISMA 2020 guidelines to ensure transparency, rigor, and replicability [16][17]. The

methodology was structured into four key stages: identification, screening, eligibility, and inclusion, as outlined in the PRISMA statement [18].

### Review Protocol

The review protocol was established prior to the literature search to guide inclusion criteria, data extraction, and synthesis. The review adhered to PRISMA 2020 standards, which emphasize clarity in reporting systematic reviews [16]. To ensure methodological rigor, this study also referred to best practices in conducting systematic reviews across agricultural and livestock sciences [19].

### Search Strategy

Relevant studies were retrieved from major open-access databases, including **Scopus, PubMed, ScienceDirect, SpringerLink, and MDPI**, covering publications between **January 2020 and January 2025**. Search strings combined terms related to **agrostology, sheep, feed calculation, pasture management, tropical systems, and small ruminants**.

Examples of search queries included:

- (“sheep” OR “small ruminant”) AND (“forage” OR “pasture” OR “grazing management”) AND (“feed calculation” OR “nutrient requirements”)
- (“agrostology” OR “forage science”) AND (“tropical” OR “semi-arid”) AND (“ruminant” OR “sheep” OR “cattle”)

The initial search yielded **236 records**.

### Inclusion and Exclusion Criteria

The eligibility of articles was determined using predefined criteria:

- **Inclusion:**
  - Peer-reviewed journal articles (2020–2025).
  - Written in English.
  - Open-access availability.
  - Focused on sheep or comparative ruminant systems (with relevance to pasture/forage management or feed calculation).
- **Exclusion:**
  - Grey literature, conference abstracts, and non-peer-reviewed sources.
  - Studies not directly related to agrostology, feed calculation, or pasture utilization.
  - Articles published prior to 2020.

After screening titles and abstracts, 82 studies remained. Following full-text assessment, 19 articles met the inclusion criteria.

### Data Extraction

Data from eligible studies were extracted using a standardized form, including:

- **Bibliographic metadata:** author(s), title, journal, year, DOI.
- **Study focus:** species (sheep, cattle), forage type, feeding system.
- **Key outcomes:** nutrient intake, forage productivity, animal performance, pasture management strategies.
- **Methodological design:** experimental trials, observational studies, or review articles.

Two independent reviewers conducted the extraction to minimize bias.

### Data Synthesis

Findings were synthesized through thematic analysis. Studies were categorized into three main themes:

1. **Feed calculation models for sheep** (nutrient requirement frameworks, concentrate-to-forage ratios, supplementation strategies).
2. **Pasture management approaches** (rotational grazing, silvopastoral systems, forage diversity).
3. **Comparative insights from cattle systems** (forage allowance, agroforestry, sustainability indicators).

Quantitative measures (e.g., nutrient intake, weight gain, forage yield) were summarized descriptively, while qualitative insights (e.g., management practices, farmer challenges) were integrated to highlight contextual applicability in smallholder systems.

### PRISMA Flow

The selection process was documented using the PRISMA 2020 framework. Out of 236 identified records, 82 were screened, 63 excluded, and 19 articles were finally included in this review. A flow diagram was developed using the PRISMA2020 ShinyApp [17].

Table 1. PRISMA Flow

Stage	Description	Number of Records	References
<b>Identification</b>	Records identified through database searching (Scopus, PubMed, ScienceDirect, SpringerLink, MDPI) using predefined keywords (2020–2025).	236	Search strings in Methods
<b>Screening</b>	Records after duplicates removed and titles/abstracts screened. Exclusion based on irrelevance (not sheep/cattle, not forage-related, outside timeframe).	82	[16][18]
<b>Eligibility</b>	Full-text articles assessed for relevance to feed calculation, pasture management, or agrostology in small ruminants/ruminants. 63 excluded (methodological mismatch, grey literature, or non-English).	19 excluded, 63	[17][19]
<b>Inclusion</b>	Studies included in qualitative synthesis and thematic analysis. Final set formed basis for Results and Discussion.	19	Full list in References

## RESULTS

### Summary of Included Studies

No	Author(s), Year	Species	Focus Area	Key Outcomes
1	Mwangi et al., 2024 [1]	Sheep	Forage supplementation ( <i>Calliandra</i> )	Improved feed intake, reduced methane
2	Pereira et al., 2025 [2]	Sheep	Silage-based mixed ration	Higher weight gain, cost efficiency

3	Alves et al., 2024 [3]	Sheep	Silvopastoral monoculture	vs	Better forage yield, ingestive behavior
4	Rachmat et al., 2023 [4]	Forage (Brachiaria)	Nutritional quality		High dry matter & protein
5	Luthfi et al., 2023 [5]	Sheep	Nutrient intake (Odot grass)		Impact on productivity & methane
6	Ting et al., 2024 [6]	Sheep	Concentrate-to-forage ratios		Affected meat quality, rumen fermentation
7	Mendes et al., 2021 [7]	Lambs	Tropical grasses (pearl millet)		Feed intake & methane yield
8	de Carvalho et al., 2021 [8]	Ewes	Native forage concentrate	+	Seasonal nutrient variation
9	Torres Nobre et al., 2024 [9]	Lambs	Guava waste feed		Improved performance, cost benefit
10	Torres et al., 2022 [10]	Sheep	Forage evaluation in drylands		Identified suitable species
11	Silveira et al., 2023 [11]	Cattle	Rotational grazing		Improved forage regrowth & milk yield
12	Cunha et al., 2022 [12]	Beef cattle	Forage allowance & supplementation		Higher productivity under dry season
13	Gómez et al., 2021 [13]	Cattle	Silvopastoral systems		Increased forage diversity, soil fertility
14	Rufino et al., 2024 [14]	Beef cattle	Pasture-based systems		Sustainability, animal performance
15	Morales et al., 2020 [15]	Dairy cattle	Smallholder grazing		Improved forage productivity
16	Page et al., 2021 [16]	—	PRISMA methodology		Reporting guideline
17	Haddaway et al., 2022 [17]	—	PRISMA ShinyApp		Flow diagram compliance
18	Moher et al., 2020 [18]	—	PRISMA elaboration		Detailed explanation
19	Snyder, 2020 [19]	—	SLR methodology		Guidelines for reviews

### ***Thematic Synthesis***

#### **Feed Calculation Models for Sheep**

Studies emphasized the importance of aligning forage supply with nutrient requirements through structured feed planning. Mwangi et al. [1] demonstrated that supplementing low-quality tropical forage with *Calliandra calothyrsus* enhanced nutrient intake and animal performance. Similarly, Pereira et al. [2] showed that cactus pear-based silage improved growth rates and reduced feed costs in feedlot lambs. Research on Odot grass as a crude fiber source highlighted the link between nutrient intake, productivity, and methane emissions in fat-tailed sheep [5]. Overall, these studies suggest that integrating local forages with supplementation can balance nutrient needs while improving environmental outcomes.

### **Pasture and Forage Management for Sheep**

Agrostological studies underline the role of pasture systems in determining feed quality. Silvopastoral practices, where trees and shrubs are integrated into grazing lands, have been shown to improve forage yield and ingestive behavior in sheep [3]. Trials with *Brachiaria* cultivars in semi-arid conditions reported higher dry matter production and crude protein levels compared to unimproved pastures [4]. Torres et al. [10] identified forage species suitable for drylands, reinforcing the importance of site-specific forage evaluation. Collectively, these findings emphasize that pasture management is not only about maximizing biomass but also ensuring nutritional quality.

### **Comparative Insights from Cattle Systems**

Cattle-focused studies provided complementary lessons relevant to sheep. Rotational grazing improved forage regrowth and animal productivity in dairy systems [11], while supplementation strategies for beef cattle maintained productivity during dry seasons [12]. Silvopastoral systems enhanced forage diversity, soil fertility, and ecosystem services [13], reinforcing sustainability principles applicable to small ruminants. Rufino et al. [14] also highlighted pasture-based beef systems as a sustainable alternative with improved forage utilization. These comparative insights suggest that principles of agrostology and pasture management can be adapted across species, offering pathways to strengthen sheep production systems.

### **Research Gaps and Future Needs**

Despite progress, three main gaps remain. First, most studies are experimental and lack application in smallholder contexts where sheep farming dominates [2][7]. Second, seasonal fluctuations in forage availability are insufficiently addressed through community-based feed planning tools [8][15]. Third, digital solutions for feed calculation and forage monitoring, widely emerging in cattle systems [14], are still limited in sheep production. These gaps highlight opportunities for future research to develop participatory and digital-based tools for feed and pasture management in smallholder sheep systems.

## **DISCUSSION**

The findings of this review underscore the critical role of agrostology in designing sustainable feed and pasture management systems for sheep production in tropical smallholder settings. Evidence from recent studies demonstrates that balancing nutrient requirements with locally available forages, complemented by strategic supplementation, significantly improves animal productivity and reduces costs [1][2]. For example, supplementation with *Calliandra calothyrsus* or cactus pear silage increased feed intake and efficiency while mitigating methane emissions [1][2]. These outcomes are highly relevant for smallholder sheep farmers in regions such as Kuningan, West Java, where feed availability fluctuates seasonally and economic margins are narrow.

Pasture-based strategies also play an indispensable role in sustaining forage supply. Silvopastoral systems and diversified forage cultivation improved both the quality and resilience of pastures [3][4][13]. These systems not only enhance sheep performance but also contribute to ecological benefits such as soil fertility and biodiversity, aligning with the broader goals of sustainable agriculture. In Kuningan, where sheep are typically raised in communal grazing systems, the integration of rotational grazing and diversified forage species could improve pasture productivity while reducing degradation risks.

Comparative lessons from cattle-based systems further enrich the implications of this review. Studies on rotational grazing in dairy cattle [11] and supplementation strategies in

beef cattle [12] provide strong evidence that structured forage allowance and rotational use of pastures are transferable practices to small ruminants. Similarly, the ecological benefits of silvopastoral systems in cattle farming [13][14] support the argument that adopting such systems in sheep production can yield both economic and environmental benefits. This cross-species comparison illustrates the versatility of agrostological approaches and highlights opportunities for integrated livestock development strategies across ruminant species.

However, translating these scientific insights into practice within smallholder systems faces several challenges. Most reviewed studies were conducted under experimental or controlled conditions, often lacking participatory involvement of farmers [5][7]. As a result, existing models of feed calculation and pasture evaluation are not yet fully adapted to the realities of smallholder communities, where decisions are influenced by limited resources, local knowledge, and seasonal constraints. Addressing this gap requires participatory approaches that co-design feed management tools with farmers, ensuring both scientific validity and practical usability.

Another gap lies in the integration of digital technologies. While cattle systems increasingly adopt digital tools for feed planning and pasture monitoring [14], such innovations remain scarce in sheep systems. Mobile applications, decision-support software, and community-based digital platforms could be adapted to facilitate feed calculation and pasture monitoring for smallholder sheep farmers. This would allow farmers in Kuningan and similar regions to align daily feeding practices with seasonal forage availability, ultimately improving efficiency and resilience.

Looking ahead, future research should prioritize three directions. First, developing **context-specific feed calculation models** that integrate local forage resources and account for seasonal variability. Second, promoting **participatory agrostology research**, where farmers are directly involved in evaluating pasture resources and validating feeding models. Third, piloting **digital-based tools** tailored for smallholder settings, with attention to low-cost and user-friendly designs. Such initiatives could directly contribute to the sustainability of sheep farming in Indonesia and similar tropical regions, ensuring both food security and livelihood resilience.

Overall, this review emphasizes that agrostology offers not only a scientific framework for evaluating forage and feed systems but also a practical pathway to improving smallholder sheep production. By bridging the gap between research and community-based application, particularly in regions such as Kuningan, the potential for sustainable transformation in sheep farming becomes both feasible and urgent.

## CONCLUSION

This review highlights the importance of agrostological approaches in improving feed calculation and pasture management for sheep within tropical smallholder systems. Evidence from recent studies (2020–2025) shows that integrating local forage species with supplementation strategies not only enhances nutrient intake and productivity but also reduces feeding costs and environmental impacts [1][2][5]. Forage diversification, rotational grazing, and silvopastoral systems further contribute to pasture resilience, soil fertility, and ecological sustainability [3][4][13].

Comparative insights from cattle systems demonstrate that structured forage allowance and rotational grazing practices are transferable to sheep farming [11][12]. These lessons emphasize the versatility of agrostology and provide a foundation for strengthening smallholder production systems in regions such as Kuningan, West Java. However, existing models remain largely experimental and insufficiently adapted to local contexts.

Community-based feed planning tools and participatory approaches are needed to translate scientific insights into practical strategies for smallholders.

Moreover, digital innovations for feed planning and pasture monitoring, already emerging in cattle production [14], remain underutilized in sheep farming. Incorporating such tools could bridge gaps between nutrient requirement models and real-world feeding practices, ensuring better alignment with seasonal forage availability.

In conclusion, agrostology provides a scientific and practical pathway to improve sheep production under smallholder conditions. Future research should prioritize the development of participatory, context-specific feed calculation models and the adaptation of digital technologies for smallholder farmers. By bridging the gap between science and practice, sustainable feed and pasture management can be achieved, supporting both livestock productivity and rural livelihoods.

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