



Housing and Feeding Practices in South Indian Pastoral Sheep Rearing Systems

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Abstract— Adoption of housing and feeding practices among pastoral sheep farmers in Tamil Nadu, India were examined through an ex-post facto research design involving 1,160 farmers from 12 districts across seven agro-climatic zones. The study found that 95.78% of farmers own their sheep, with 66.47% practicing daytime grazing and night-time penning. Housing practices were diverse: 60.60% used field or backyard pens and 21.03% employed closed pucca houses. Inadequate housing was prevalent, suggesting a need for improved education on proper housing techniques. Feeding practices indicated that 52.16% of farmers utilized common property land and harvested fields for grazing, with 38.28% supplementing this with additional fodder. The preference for grazing over concentrate feeds was attributed to cost and lack of awareness. Water provision was generally sufficient, with 52.33% of farmers supplying water twice daily. The findings underscore the necessity of a multifaceted approach to enhance smallholder sheep farming by addressing economic, educational, and infrastructural challenges. Addressing these issues can facilitate the transition to more sustainable and profitable practices, ultimately improving farmers' livelihoods and contributing to the broader agricultural economy in Tamil Nadu, India.



Keywords— Sheep Farming, Adoption, Housing Practices, Feeding Management, Pastoral Systems, Sustainable Agriculture

I. INTRODUCTION

Sheep, one of the oldest domesticated animals, offer a wide range of benefits and have been integral to human societies for thousands of years. They provide essential resources such as food, clothing, and textiles, and play crucial roles in land management, conservation, breeding, genetics, and cultural traditions (Senthilkumar *et al.*, 2008). Sheep contribute to environmental conservation by controlling invasive plant species, preventing soil erosion, promoting healthy vegetation growth, and enhancing soil fertility through manure, which serves as an excellent natural fertilizer (Masin *et al.*, 2018). In India, sheep

rearing is vital to the rural economy and significantly supports farmers (Karthik *et al.*, 2021). India, with a sheep population of 75.35 million, ranks second globally, representing over 4.03% of the world's sheep population (Bhateshwar *et al.*, 2022). Sheep also hold substantial cultural and economic value, influencing rural livelihoods and agricultural health. In Tamil Nadu, the sheep population of 4.5 million places the state fifth in the country, underscoring its importance within India.

This study aims to analyze the management practices adopted by sheep farmers in Tamil Nadu. By exploring these practices, the study seeks to identify gaps in the

adoption of scientific management techniques and provide insights for improving sheep farming practices. Key aspects such as breed selection, feeding management, and marketing channels are crucial for economic efficiency. Effective management practices also contribute to environmental sustainability by preventing overgrazing, soil erosion, and habitat degradation, while promoting the health and productivity of the flock through selective breeding and genetic improvement (Smith, 2024).

The findings of this study will offer recommendations for improving flock management, guiding farmers and farm entrepreneurs towards adopting best practices. By addressing gaps in the adoption of scientific feeding management practices, the study aims to enhance sheep health, farming efficiency, and environmental stewardship. This investigation into the housing and feeding systems of pastoral sheep farmers in Southern peninsular India will provide valuable insights for researchers, extension specialists, and veterinarians working to advance sheep farming practices (Saravanan *et al.*, 2020). With this in mind the study was undertaken with the specific objectives to understand the housing and feeding management practiced by pastoral sheep rearers in Tamil Nadu, India and to propose a strategy for optimum resource uses in sheep farming operations.

II. MATERIALS AND METHODS

The present study employed an ex-post facto research design. The focus was on analyzing the sustainability of sheep farmers in Tamil Nadu, India across its seven agro-climatic zones. To capture a comprehensive picture of sheep farming in the state, one or two districts with the highest sheep populations were selected from each zone, resulting in a total of 12 districts.

Within each selected district, two blocks with the highest sheep populations were identified, leading to the inclusion of 24 blocks. In these blocks, cluster of villages with a significant concentration of sheep farming activities were chosen, selecting five to six villages per block. Overall, 1,160 sheep farmers were randomly selected for the study. This included 220 sheep farmers from each of the zones, except for the high-altitude and high-rainfall zones, where only 30 farmers were selected due to the lower sheep population in those areas.

III. RESULTS AND DISCUSSION

Flock size, indicating the sheep owned by an individual at the time of inquiry, was categorized into three groups: small (up to 21 sheep), medium (22 to 42 sheep), and large (above 42 sheep), owned by 53.02%, 31.90% and 15.08% respectively. This categorization was based on scientific

recommendations for effective breeding, which suggest maintaining a ratio of 20 ewes to one ram. Most farmers were landless and maintained small to medium flock size due to their poor economic resources and utilized family labour, and few hired labour based on their need exclusively for grazing, while those maintaining large flock hired labour for management and grazing of the flock.

The systems of rearing of sheep in terms of housing, feeding and watering, besides their migratory pattern were studied in detail. The results of the study indicated that a significant majority (95.78%) of respondents owned their sheep, while a small proportion (4.22%) maintained sheep under contract (Table 1). This predominance of ownership was attributed to the fact that sheep rearing was primarily the main occupation for most respondents, leading them to prefer owning and investing in sheep husbandry to maximize profitability. Conversely, the relatively low percentage of contract farmers was due to financial constraints, particularly among poorer individuals who lacked the capital to purchase sheep. Additionally, landlords seeking supplementary income often purchased sheep and leased them to experienced shepherds, resulting in a mutually beneficial arrangement. Thus, the small percentage of contract farmers reflected the economic and operational dynamics.

Table 1: Ownership status of sheep among the respondents
n=1160

Status	Frequency	Percentage
Own	1111	95.78
Contract	49	4.22
Total	1160	100.00

The results of the study indicated distinct patterns in sheep rearing practices. A significant majority (66.47%) of respondents followed a system where sheep were grazed during the day and then penned in fields or backyards at night. This was followed by practices involving a combination of stall feeding and grazing (16.72%) and migration (16.64%). A minimal proportion (0.17%) relied solely on stall feeding (Table 2).

Table 2: System of sheep rearing
n=1160

Rearing System	Frequency	Percentage
Grazing	771	66.47
Stall feeding + grazing	194	16.72
Migration	193	16.64
Stall feeding	2	0.17
Total	1160	100.00

The predominant use of grazing reflected farmers' reliance on available vegetation from common property lands and harvested fields. This practice was largely due to limited scientific knowledge about feeding and insufficient financial resources (Shinde & Sejian, 2013). Farmers appeared to prioritize cost savings on feed, but this approach resulted in reduced productivity due to lack of supplementary concentrates.

Stall feeding was more common among farmers with access to agricultural by-products after the harvest and some used tree fodder, particularly among landowners. The preference for grazing can be attributed to the natural grazing behavior of sheep, which prefer grass. The influence of the monsoon season on agricultural patterns also played a role, as it allowed farmers to effectively use grazing during migration (Seo, 2016). For those aiming for quicker weight gain, stall feeding with concentrates and cultivated grass was preferred. Additionally, the shrinkage of land availability led some farmers to adopt stall feeding as a practical alternative.

The study revealed diverse approaches to sheep housing among respondents. A predominant majority (60.60%) chose to pen their sheep in farm fields or backyards (Table 3). In contrast, over one-fifth (21.03%) used closed pucca houses, while 11.73% employed a combination of closed houses and penning, and 6.64% utilized closed kutchas.

Table 3: Type of housing practised

n = 1160

Type of housing	Frequency	Percentage
Penning	703	60.60
Closed pucca	244	21.03
Closed pucca + penning	136	11.73
Closed kutchas	77	6.64
Total	1160	100.00

This distribution of housing practices suggests that many farmers did not prioritize scientific housing methods, due to financial constraints and concerns about the economic burden of such investments (Autio *et al.*, 2021). Consequently, inadequate housing may have resulted in poor hygienic conditions and compromised sheep health. Addressing this issue through education on the benefits of proper housing could significantly enhance productivity and overall flock well-being.

The study revealed that more than half (54.05%) of the respondents did not provide separate enclosures for lambs, maintaining them with the main flock (Table 4).

Table 4: Housing provided for lamb

n = 1160

Enclosures for lamb	Frequency	Percentage
Separate enclosures for lamb	158	13.62
Separate with ewe	375	32.33
Along with the flock	627	54.05
Total	1160	100.00

This practice indicated that many farmers preferred to keep lambs integrated with the adult sheep, based on the belief that it was natural for lambs to remain with the flock. In contrast, about one-third (32.33%) of respondents chose to house lambs with ewes, which allowed for some separation from the rams while keeping them close to their mothers. This method was intended to ensure that lambs received maternal care but did not involve distinct enclosures. Only a small proportion (13.62%) of farmers established separate enclosures specifically for lambs. This limited adoption was often due to the perception that separate enclosures might isolate the young animals, rather than providing additional benefits (Best *et al.*, 2021). Farmers with larger land holdings were more likely to provide dedicated enclosures for lambs, reflecting their capacity to invest in specialized care and management practices. This approach allowed for better management of lambs, contributing to their growth and health. Overall, the findings suggested that while many farmers maintained lambs with the flock or with ewes, there was potential benefit in educating them about the advantages of separate enclosures for lambs, particularly in enhancing their health and development.

The study showed that the average grazing time for sheep was eight hours during the summer, 7.1 hours in winter, and 6.3 hours during the rainy season (Table 5). This variation in grazing time was influenced by seasonal factors. During summer, the longer daylight hours allowed farmers to graze their sheep for extended periods. Additionally, the scarcity of grass in summer necessitated longer grazing times. Conversely, shorter days in winter and the rainy season led to reduced grazing durations, as farmers had to return home earlier. In winter, the decreased daylight limited grazing time, while the rainy season provided abundant grass and fodder, reducing the need for extended grazing. However, heavy rains often prevented grazing altogether, posing challenges due to diverse weather conditions and their negative impact on both the sheep and the shepherds (Nota *et al.*, 2020).

Table 5: Details on grazing of sheep

Time / Distance	Season	Hours / Kms
Average grazing time (in hours)	Summer	8.0
	Winter	7.1
	Rainy	6.3
Distance travelled / range (in km)	Summer	2.8-5.9
	Winter	2.3-4.8
	Rainy	1.9-4.1

The distance travelled for grazing was greater in summer (ranging from 2.8 to 5.9 km) compared to the rainy season (ranging from 1.9 to 4.1 km). The reduced distance during the rainy season was attributed to marshy land conditions and the risk of diseases affecting the sheep. Farmers minimized travel during this period to avoid stressing the animals, which could increase their susceptibility to illnesses.

The study revealed that over half of the respondents (52.16%) utilized common property land resources and harvested fields for grazing their sheep, while more than one-third (34.20%) grazed their sheep solely in common property resources. A smaller proportion (9.41%) used harvested fields alone, 3.02% grazed in forests, hills, and nearby lakes, and only 1.21% utilized pasture land (Table 6). In Tamil Nadu, the extensive availability of common property land resources was effectively utilized by sheep farmers. This practice was advantageous not only for grazing but also for maintaining ecological balance. Although the law permitted grazing sheep in forest and hilly areas, only a few respondents used these areas. The limited use of forests and hilly tracts was likely due to challenges such as difficult terrain and bureaucratic hurdles, including conflicts with forest department officials and the difficulty of obtaining grazing permits.

Table 6: Location where sheep were allowed for grazing

n = 1158

Grazing area	Frequency	Percentage
Common property resources + harvested field	604	52.16
Common property resources	396	34.20
Harvested field	109	9.41
Forest, hills and nearby lake	35	3.02
Pasture land	14	1.21
Total	1158	100.00

The study found that a substantial majority (87.05%) of respondents hired external labour for grazing their sheep, while only a small proportion (12.95%) utilized family

members for this task (Table 7). Given that grazing is a time-consuming activity, sheep owners preferred to employ shepherds who could dedicate their time and expertise to this work. The hired shepherds typically possessed extensive experience in various aspects of grazing, including navigating the right grazing tracks, identifying and managing their sheep, and protecting them from predators (Myers, 2024). This expertise was crucial for effective grazing and maintaining the health and safety of the flock.

Table 7: Details on labour utilised for grazing

n = 1158

Type of labour	Frequency / wages	Percentage
Hired	1008	87.05
Family	150	12.95
Average wages/Total	Rs. 12,500 / month	100.00
Range	Rs. 10,000 to 15,000	

On an average, the monthly wages paid to hired shepherds amounted to Rs. 12,500. This level of compensation provided the labourers with a subsistence income, allowing them to support themselves. Due to the specialized nature of the grazing work and the lack of skills in other areas, these labourers often remained employed in this role to sustain their livelihoods. It is noteworthy that nearly two-fifths (38.28%) of respondents supplemented grazing with additional feeding of fodder that was cut specifically for their sheep (Table 8). This fodder was cultivated within the respective zones as part of agricultural production. The cultivated fodder was utilized for feeding sheep during periods of scarcity or as a supplement to grazing, in addition they were used for feeding dairy cattle, composting, bedding material for animals, mulching *etc.*

Typically, sheep farmers were adept at identifying poisonous plants. As a result, the incidence of sheep affected by poisonous plant consumption was relatively low, at 1.38% (Table 9). The primary reason for the rare occurrences of poisoning was that during the monsoon season, the proliferation of unwanted poisonous plants often occurred, leading to their mixing with fodder crops. Despite this, the farmers' ability to identify and avoid these harmful plants contributed to the low incidence of poisoning among their sheep.

This practice aimed to enhance the nutritional intake of their sheep, potentially leading to improved weight gain and reproductive performance. In contrast, majority (60.00%) of respondents relied solely on grazing without any supplementary concentrate feed. The preference for grazing alone among these farmers was largely due to a

lack of awareness about the benefits of concentrate feeding (Stampa *et al.*, 2020). Many respondents did not recognize the advantages of providing concentrates, which include accelerated weight gain and better reproductive outcomes. This gap in knowledge, coupled with concerns about the cost of concentrates, led to the predominant use of grazing as the sole feeding method.

Table 9: Incidence of sheep affected due to grazing on poisonous plants

n = 1158

Incidence	Frequency	Percentage
Yes	16	1.38
No	1142	98.62
Total	1158	100.00

The study indicated that 40.00% of respondents provided concentrates in addition to grazing or stall feeding of green fodder (Table 10).

Table 10: Feeding of concentrates to sheep

n = 1160

Type of feeding	Frequency	Percentage
Provide concentrates + grazing / stall feeding	464	40.00
Only grazing (no concentrate feeding)	696	60.00
Total	1160	100.00

Table 8: Fodder utilisation pattern in addition to grazing by the respondents in different agro-climatic zones of Tamil Nadu

N = 1160				
Zone	Fodder produced	Frequency	Frequency	%
Cauvery delta*	Hariyali (Bermuda grass)	104	109	49.55
	Sunflower, cotton	3		
	Tapioca, sugarcane	2		
High altitude**	Carrot, potato, beetroot, cabbage	1	1	3.33
High rainfall**	Hariyali	29	30	100.00
	Agathi (Sesbania grandiflora), velimasal (Desmanthus)	1		
North-eastern*	Sunflower, paddy	1	2	0.91
	Groundnut (Peanut)	1		
North-western*	Cholam (Sorghum)	1	29	13.18
	Cholam, pearl millet, sesame	3		
	Cholam, sesame, tapioca	2		
	Groundnut	3		
	Groundnut, sesame, cholam	1		
	Groundnut, cholam	3		
	Groundnut, sesame	4		
	Groundnut, green gram	1		
	Hariyali	1		
	Ragi, tomato	1		
	Sesame, cholam	2		
	Soobabul (Leucaena leucocephala), cholam	1		
	Tapioca, cholam	6		
Southern*	Agathi	17	217	98.64
	Agathi, hariyali	1		

	Agathi, velimasal	11		
	Hariyali, velimasal	7		
	Hariyali	180		
	Hariyali, agathi, velimasal	1		
Western*	Cotton	1	56	25.46
	Groundnut	1		
	Hariyali	31		
	Murungai (Drumstick), sorghum, coconut	1		
	Sunflower, cotton	14		
	Tapioca, sugarcane	6		
	Thattai payaru (Cowpeas), banana	1		
	Turmeric, coconut	1		
Sub-total			444	38.28
Respondents not feeding fodder in addition to grazing			716	61.72
Total			1160	100.00

*n=220; **n=30

Furthermore, lack of proper education and understanding about the role of concentrates in sheep nutrition contributed to the limited adoption of this practice. As a result, many farmers missed out on the potential benefits that concentrate feeding could offer in terms of enhancing the overall productivity and health of their flock. The study found that a significant proportion of respondents provided additional feed to their lambs, including green fodder, tree fodder, dry fodder, and concentrates (Table 11). This practice indicated a higher level of attention given to lambs compared to rams and ewes. Only a small percentage of respondents supplemented rams and ewes

with extra feed, and minimal use of salt was observed, with none of the respondents providing mineral mixtures.

The use of locally available, non-conventional feeds, which are often free or low-cost, was common among the farmers. This approach reflects an effort to maximize the use of readily accessible resources. The increased emphasis on feeding green fodder, dry fodder, and concentrates to lambs highlighted the farmers' focus on improving the growth and weight of young sheep. This strategy aimed to enhance lambs' market value, thereby achieving better financial returns during sales.

Table 11: Distribution of sheep on feeding apart from grazing

n = 1160

Type of feed	Species	Frequency*	Percentage
Green fodder (agathi, cholam, hariyali, velimasal, sorghum, tapioca)	Ram	24	2.07
	Ewe	24	2.07
	Lamb	125	10.78
Tree fodder (banyan, agathi, soobabul and neem)	Ram	45	3.88
	Ewe	45	3.88
	Lamb	181	15.60
Dry fodder (dried groundnut leaves, dried sunflower leaves, sorghum, sugarcane waste, tapioca leaves and vidanga (Embelia ribes))	Ram	206	17.76
	Ewe	208	17.93
	Lamb	174	15.00
Concentrates (bran, groundnut oil cake, ragi, horsegram, groundnut, cattle feed, cereals, sorghum, tapioca thippi,	Ram	137	11.81
	Ewe	138	11.90

cholam, cumbu, coconut cake, cotton seed, rice water, legume crop residues, rice bran and wheat bran)	Lamb	146	12.59
Salt	Ram	5	0.43
	Ewe	5	0.43
	Lamb	8	0.69
Mineral mixture	Ram	0	0.00
	Ewe	0	0.00
	Lamb	0	0.00

*Multiple responses not to total

The study assessed the sources of drinking water for sheep, as detailed in Table 12. The results revealed that one-third (33.88%) of the respondents utilized a combination of tanks, ponds, and canals to provide drinking water for their sheep. Following this, 28.45% of respondents relied on check dams, lakes, wells, pipelines, rivers, and pumps for their water needs. Additionally, one-quarter (24.05%) of respondents used ponds exclusively for supplying water.

Table 12: Water source for sheep

n = 1160

Source	Frequency	Percentage
Tank, pond and canals	393	33.88
Check dams, lakes, wells, pipelines, rivers and pumps	330	28.45
Ponds	279	24.05
Canals	127	10.95
Tanks	31	2.67
Total	1160	100.00

The findings indicated that farmers made extensive use of all available water resources to meet the drinking needs of their sheep. Many preferred stagnant water sources such as tanks and ponds. However, in areas with irrigation facilities and along river belts, running water was favoured due to its availability and also due to lowered risk of contamination. This preference for running water highlights its perceived benefits over stagnant sources, including better quality and safety for the sheep.

The study found that more than half (52.33%) of the respondents provided water to their sheep twice a day, while over one-third (36.21%) supplied water three times daily (Table 13).

A smaller proportion of respondents offered water more frequently. The results indicated that farmers were aware of the water requirements of their sheep. Given that sheep are hardy animals capable of surviving on minimal vegetation and dry conditions, farmers adjusted their water

provision practices accordingly. They provided an adequate amount of water based on the animals' need and environmental conditions, reflecting their understanding of sheep's resilience and water needs.

Table 13: Frequency of watering sheep

n = 1160

Number of times/days	Frequency	Percentage
Two times	607	52.33
Three times	420	36.21
4 to 5 times	91	7.84
Ad-libidum	42	3.62
Total	1160	100.00

The study revealed that three-quarters (75.52%) of the respondents had access to reliable water sources throughout the year, which facilitated the provision of optimal feed and water for their sheep (Table 14). This consistent availability of water was beneficial for maintaining the health and productivity of the sheep. Conversely, one-quarter (24.48%) of respondents faced challenges in accessing sufficient water during the summer months, particularly between April and May. During these peak summer periods, the scarcity of water placed stress on the animals and made management more difficult for the farmers. This seasonal water shortage highlighted the need for improved water resource management to ensure the well-being of the sheep throughout the year.

Table 14: Availability of water source over the year

n = 1160

Water availability	Frequency	Percentage
All through the year	876	75.52
July to February	284	24.48
Total	1160	100.00

The details of sheep migration by nomadic farmers are outlined in Table 15. Only 16.64% of the farmers practiced total migration with their flocks. Among these, nearly two-

thirds (61.14%) of the flock owners or their relatives accompanied the sheep during migration, while the remaining 38.86% hired labour for this task. Among those accompanying the flock, majority (57.51%) travelled in groups of four to five on a rotational basis, followed by a group size of six to seven members (30.57%) and with a group size ranging from a minimum of two to three (11.92%). The sheep were grazed for an average of 10 hours by 67.88% of the farmers, while 32.12% provided eight hours of grazing per day. Nearly half (48.70%) of the respondents sold animals during migration, primarily due to stress-related issues such as diseases, injuries, or old age. Additionally, 54.92% of the farmers included lambs in the migration process, as lambs required extra care that would be challenging to provide if left at home. The average distance travelled by the flocks was 10.53 kilometres.

The selection of halting places during migration was influenced by factors such as the availability of feed, water, penning facilities, the cost of penning, familiarity with landowners, and traditional resting spots (Wafula et al., 2022). Migratory challenges included outbreaks of disease, predator threats, insufficient fodder and water, family maintenance issues, poor transportation access, and conflicts with local residents (Hadjikyriakou et al., 2020). Typically, dogs and goats accompanied the sheep to provide protection and to assist in guiding the flock. Shepherds faced significant hardships during migration, including the stress of long-distance travel and the difficulties associated with night halts in open agricultural fields. These conditions posed risks from predators and harmful reptiles, further complicating the shepherds' tasks.

Table 15: Details on migration of sheep

n = 193 (16.64 per cent)

S. No.	Particulars	Frequency	Percentage
1	Persons taking animals for migration		
	Owner / relative of the owner	118	61.14
	Hired labour	75	38.86
2	Number of persons accompanying the flock		
	Group of 6 to 7 on rotation	59	30.57
	4 to 5 members	111	57.51
	2 to 3 members	23	11.92
3	Duration of grazing per day		
	8 hours of grazing	62	32.12

	10 hours of grazing	131	67.88
4	Selling during migration		
	Number of farmers	94	48.70
5	Take lambs during migration	106	54.92
6	Halting places decided based on	Availability of feed, water, penning facilities, price paid for penning, known land owners, traditional places	
7	Water sources	Pond, lake, canal, stream and river	
8	Average distance travelled per day	10.53 km	
9	Problems encountered	Disease outbreak, predators' problem, lack of fodder and water, nomadic life, family maintenance, transport, conflict with native people.	
10	Other animals accompanying	Dogs, goats	

Out of the seven agro-climatic zones studied, the high-altitude zone was characterized by its hilly terrain and extreme weather conditions, which made migration impractical. Due to these challenging environmental factors, sheep farmers in this zone did not engage in migration practices. In contrast, migration was a prevalent practice in the other six agro-climatic zones. However, within the North-Western zone, which includes the districts of Salem and Dharmapuri, migration was notably absent. The respondents from these districts did not practice migration, likely due to local factors that rendered this practice less feasible or necessary. For the remaining six zones, migration was actively practiced by sheep farmers. This suggests that in regions with more favorable conditions for movement, migration was a viable and possibly beneficial strategy for managing sheep, likely influenced by factors such as the availability of grazing resources and the seasonal variation in feed availability. The absence of migration in the North-Western zone highlights a distinct regional practice within the broader context of sheep farming in Tamil Nadu, India. It underscores the influence of specific local conditions on the adoption of migration practices and suggests that while migration is a common strategy in many zones, its

applicability varies based on environmental and logistical constraints.

STRATEGY FOR OPTIMUM RESOURCE USES IN SHEEP FARMING OPERATIONS IN PASTORAL SYSTEM IN TAMIL NADU, INDIA

Best practices for adoption of sheep farmers in pastoral system

Based on the study's findings, a comprehensive strategy can be devised to emulate best practices in sheep farming. This strategy aims to enhance profitability, improve sheep health and productivity, and ensure sustainable management practices.

1. Encouraging ownership and investment in sheep husbandry

- **Promotion of ownership:** The predominance of sheep ownership (95.78%) suggests that investing in sheep rearing is financially beneficial for farmers who view it as their primary occupation. Support programs should be designed to provide financial aid or microloans, enabling more farmers to own their sheep rather than depend on contract arrangements.
- **Contract farming support:** For the 4.22% who maintain sheep under contract, financial support and training should be provided to help them for transition to ownership. Additionally, promoting cooperative ownership models could provide a feasible option for farmers with limited capital.

2. Improving rearing systems

- **Optimizing grazing practices:** With 66.47% of farmers relying primarily on grazing, it is essential to educate them on the benefits of incorporating supplementary feeding with concentrates, which only 40% currently practice. This could lead to improved productivity and profitability.
- **Stall feeding integration:** For farmers with limited grazing land, the promotion of stall-feeding practices combined with grazing can be effective. Emphasizing the benefits of controlled feeding environments, especially during monsoon seasons, could reduce the risk of diseases and improve sheep health.

3. Enhancing housing practices

- **Advocating scientific housing:** Since 60.60% of farmers currently pen their sheep in open fields or backyards, there is a need to educate them on the benefits of closed and semi-closed housing systems. Training programs and subsidies for building proper sheep housing could improve hygiene and reduce disease incidence.

- **Separate enclosures for lambs:** Promoting the practice of providing separate enclosures for lambs, which only 13.62% of farmers currently follow, could lead to better growth rates and lower mortality. Educating farmers on the benefits of taking care of their lambs could increase the adoption of this practice. Also, it will protect lambs from the predators, especially at night.

4. Optimizing grazing time and watering practices

- **Seasonal grazing adjustments:** Given the seasonal variations in grazing time (8 hours in summer, 7.1 hours in winter, 6.3 hours in the rainy season), farmers should be encouraged to adjust their grazing strategies to ensure optimal feeding and reduce stress on the sheep. Additionally, access to supplementary feed during shorter grazing periods should be promoted.
- **Water management:** With 75.52% of respondents having year-round access to water, best practices in water conservation and management should be shared with those facing seasonal shortages (24.48%). Implementing rainwater harvesting and efficient water storage systems can help maintain consistent water supply.

5. Addressing labour and migration issues

- **Supporting hired labour:** As 87.05% of farmers rely on hired labour for grazing, training programs should be developed for shepherds to enhance their skills in sheep management, disease prevention, and safety during migration. This can improve overall flock health and reduce the risks associated with grazing.
- **Improving migration practices:** For the 16.64% of farmers who migrate with their flock, providing support in the form of mobile health services, access to grazing permits, and information on safe halting spots can reduce the challenges and risks associated with migration. Also support by governments or NGOs in terms of shelter and water tubs in the migratory routes will help and encourage nomadic farmers to continue migratory system of sheep rearing that promote ecological balance too.

6. Promoting fodder cultivation and supplementary feeding

- **Encouraging fodder cultivation:** With 38.28% of farmers supplementing grazing with cultivated fodder, there is potential to increase this percentage by promoting fodder crops that can be grown alongside other agricultural activities. This could reduce reliance on grazing and improve sheep nutrition.

- **Expanding concentrate feeding:** Educating farmers on the benefits of concentrate feeding, especially for lambs and pregnant ewes, can lead to improved growth rates and overall flock health. This practice should be coupled with information on cost-effective concentrate options and proper feeding techniques.

7. Health management and poisonous plant avoidance

- **Training on poisonous plant identification:** Despite a low incidence (1.38%) of sheep affected by poisonous plants, continuous training on identifying and avoiding these plants is essential. Providing farmers with resources and tools for early detection and treatment can further reduce the risks. Also training farmers on ethno-veterinary applications will help to use local herbal resources effectively especially in remote areas.
- **Regular health checks:** Implementing regular health checks and vaccination programs can prevent disease outbreaks and improve overall flock health. Mobile veterinary services could be particularly beneficial for farmers in remote areas.

To implement this strategy effectively, a combination of government initiatives, cooperative efforts, and private sector partnerships is essential. Extension services should be strengthened to provide ongoing education, technical support, and access to resources. By focusing on these areas, sheep farmers can enhance their practices, leading to increased profitability and sustainability in sheep.

Implications

The study on smallholder sheep farming practices in the region reveals critical insights into the challenges and opportunities faced by these farmers. The findings have significant implications for the future of sheep farming, particularly concerning the sustainability and profitability of these operations.

One of the most striking implications is the overwhelming preference for grazing-based systems among smallholder farmers. This choice is primarily driven by economic constraints, as grazing is perceived as the most cost-effective method for feeding sheep. However, this reliance on traditional grazing practices also points to the limitations in resources faced and knowledge these farmers possessed. Grazing, though economical, is heavily dependent on the availability of pasture, which can be inconsistent due to seasonal variations and climate change. This variability poses a risk to the stability of sheep farming operations, especially during periods of feed scarcity that consequently, reduced productivity.

The study also highlights the reliance on external labour for grazing the sheep. This dependence underscores a

vulnerability within these farming systems, where the availability and cost of labour can significantly impact operations. To mitigate this, there is a clear need for capacity-building initiatives that focus on skill development among family members involved in sheep farming. By equipping family members with the necessary skills, farmers can reduce their reliance on external labour, thereby lowering costs and increasing the resilience of their farming systems.

Another critical implication of the study is the evident gap in scientific knowledge and financial resources among smallholder farmers, particularly concerning feeding and housing practices. Most farmers do not have knowledge and access to scientific feeding methods, such as concentrate supplementation, which could significantly enhance sheep health and productivity. This under-utilization of improved feeding practices is indicative of broader systemic issues, including limited access to education and training programs. Without the knowledge and resources to implement these practices, farmers are unable to optimize the productivity and health of their sheep, leading to suboptimal economic outcomes.

The lack of proper housing infrastructure is another area of concern. Many farmers rely on rudimentary housing for their sheep, which can lead to health issues, particularly in harsh weather conditions. Improving housing facilities is crucial for maintaining the health and productivity of sheep, especially during extreme weather events. However, the financial constraints faced by many smallholder farmers make it difficult for them to invest in better housing infrastructure.

To address these challenges, there is a pressing need for targeted interventions that provide farmers with better access to resources, education, and training. Extension services should be developed to focus on modern feeding practices, animal health management, and sustainable grazing techniques. These services can play a crucial role in bridging the knowledge gap and helping farmers adopt more efficient and effective farming practices.

Financial support mechanisms, such as subsidies, microloans, or grants, could also play a pivotal role in empowering farmers to invest in better feeding and housing infrastructure. By providing financial assistance, these mechanisms can help alleviate the economic pressures that hinder the adoption of improved practices.

Moreover, policy interventions should prioritize the development of infrastructure that supports sustainable sheep farming, in terms of providing capacity building, input support and maintaining common property resources for grazing with the support of local government bodies through the established training centers or research farms

of the State Veterinary Universities and line departments. Effective dissemination of best practices through outreach centers, cooperatives and NGOs and best use of social media with authenticated message will promote livelihood of targeted sheep rearers. These initiatives could create a more conducive environment for smallholder farmers to thrive, ensuring the long-term sustainability and profitability of sheep farming in the region.

IV. CONCLUSIONS

The study underscores the need for a multifaceted approach to improving smallholder sheep farming. By addressing the economic, educational, and infrastructural challenges, stakeholders can help smallholder farmers transition to more sustainable and profitable farming practices, ultimately enhancing their livelihoods and contributing to the broader agricultural economy.

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