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Optimising forage resources for goats through silvipastoral systems

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Goat farming plays a significant role in rural livelihoods, particularly for small and marginal farmers. However, fodder scarcity and degraded grazing lands pose challenges to sustainable goat production. Goats exhibit selective feeding behaviour, preferring browse materials over grasses, which influences their dietary intake and productivity. The silvipastoral system integrates trees, shrubs, and pasture, offering a sustainable solution to fodder shortages. This system not only enhances biomass availability but also improves soil fertility and livestock health. Various tree and shrub species, such as Leucaena leucocephala, Grewia optiva *and* Morus alba *provide high-quality fodder across different agro-climatic regions.*

Keywords: Fodder, Goat farming, Grazing habits, Nutritional value

GOAT is one of the earliest animals domesticated by humans. It adapts easily to various climatic conditions and can survive on a wide range of fodder. Goat, known for its resilience, thrives even with minimal resources, earning the title of the 'Poor man's cow'. It is multi-functional animal and plays a significant role in economy and nutrition of landless, small and marginal farmers in the country. In addition to providing meat and milk, they also provide skin, fibres, bones, hooves, horns, blood and manure in substantial quantities. Therefore, rearing of goats is gearing up at faster rate with an annual population growth rate of 10.01% in the country. Their small size makes them easy to manage, requiring less space and allowing women and children to handle them with ease. In India, goats are among the most profitable livestock due to their fast reproduction cycle and adaptability to various ecological conditions. But in the present situation, due to scarcity of good quality feed and fodder, it has become very difficult to rear goats for efficient production.

The area under permanent pastures and grazing lands is declining in the country, and restricted access to forest resources has further exacerbated the shortage of feed and fodder for livestock. According to the United Nations Convention to Combat Desertification (UNCCD) in 2019, India lost 31% (5.65 million hectares) of its grasslands between 2005 and 2015. Estimates from ICAR-Indian Grassland and Fodder Research Institute (2019-20) indicated that grasslands and grazing lands in India extend over roughly 11.5 million hectares, representing about 3.5% of the country's total geographical area. In contrast, Himachal Pradesh records the highest proportion among states, with nearly 16.38% of its area classified as grasslands. In open grazing areas, goat primarily feed on grasses, small plants and woody shrubs. In an intensive or semi-intensive system, proper feeding arrangements should be made to meet their nutritional needs. Understanding goat behaviour during grazing and browsing is crucial for improving their management. Knowing their behavioural patterns helps create a suitable environment that maximises resource use and boosts productivity. Goats can achieve their highest production efficiency when they are raised and managed according to their natural behaviour and developmental needs at different life stages.

Nutritional requirements of goats

Goats are small ruminants characterised by their unique feeding behaviour and high sensitivity to environmental conditions. Their actively mobile upper lips and highly grasping tongue enable them to graze efficiently on short grasses as well as browse leaves and twigs from trees and shrubs. Typically, goats spend 5–8 h daily in grazing and browsing to meet their maintenance requirements. The average feed intake of goats ranges between 3–4% of body weight on a dry matter basis per head per day. This intake is affected by several factors, including body weight, dry matter content of the fodder (12–35% in fresh forages and 86–92% in hays and concentrates), palatability, and the physiological stage of the animal (growth, pregnancy, or lactation).

Nutrient requirements in goats are primarily dictated by physiological state, with growing animals showing a steadily increasing demand to support both maintenance and body development. In contrast, reproducing goats have the lowest nutrient requirement during the dry or mating period, which gradually increases during gestation and peaks at lactation, when metabolic demands are at their highest. The tables given in the article provide standardised recommendations on nutrient intake, dietary regimens, and mineral supplementation, which serve as critical guidelines for sustainable goat feeding management.

Table 1. Nutritional requirements for maintenance in adult goats

BW (kg)	DMI (g)	DM (% BW)	DCP (g)	TDN (g)	Ca (g)	P (g)
15	500	3.3	23	240	1.1	0.7
20	625	3.1	29	295	1.3	0.9
25	730	2.9	34	350	1.6	1.1
30	830	2.8	39	400	1.8	1.2
35	940	2.7	44	450	2.1	1.4
40	1,040	2.6	48	500	2.3	1.5
45	1,125	2.5	53	540	2.5	1.7
50	1,230	2.4	57	590	2.7	1.8
55	1,315	2.4	62	630	2.9	1.9
60	1,410	2.3	66	675	3.1	2.1

Source: Ranjhan (1998).
BW, Body Weight; DMI, Dry Matter Intake; DM, Dry Matter; DCP, Digestible Crude Protein; TDN, Total Digestible Nutrients; Ca, Calcium and P, Phosphorus.

Feeding behaviour of goats

The grazing period of goats is longer than the sheep due to their high selectivity and mobility. Their front incisors allow them to chew bark and shred grass efficiently. Goats drink by sucking, and their water intake increases with temperature, pregnancy, and lactation. They graze in varied terrains, including hills and rocky inclines, and can cover 14–15 km/day. Factors like climate, pasture quality, herd size, age, health, and physiological status affect grazing. One of the key traits of goats is their ability to select their feed carefully, which plays a crucial role in pasture management. The level of selectivity determines whether animals consume high- or low-quality pasture, directly affecting their productivity. Goats tend to be more selective than cattle, and younger animals are generally more selective than older ones. However, the diet selection patterns in young animals can be less stable compared to adults. Goats browse in herds. Bite selection in small ruminants is affected by their preference for plant components, as well as the availability and accessibility of forage. This selection is a reflex response to the chemical and physical properties of leaves and stems. Both preference and selection are relative concepts, depending on the presence and contrast between different plant components.

Silvipastoral role in goat farming across different agro-climatic zones of India

The concept of integrating livestock, pasture, and trees is a key feature of various silvipastoral models. These systems are particularly suitable for rearing domesticated animals, especially goats, as they readily feed on woody plants. The silvipastoral system is a low-cost method for utilising marginal, sub-marginal, and wastelands effectively. These systems can be effectively established even in fertile and well-irrigated conditions, making them a highly versatile land-use option. They are designed with a holistic approach in maintaining the health of soil, plants, and animals.

Table 2. Feeding schedule for different category of goats

Category of goat	Approximate body weight(kg)	Concentrate (g/day)	Green fodder (kg/day)
Growing (6–12 months)	15–20	300–400	1–2
Adult goats	25–30	200–300	2–3
Breeding bucks	30–40	400–500	3–5

Source: Nipane *et al.* (2023).

Table 3. Prevalent components of silvipastoral system in the different agro-climatic zones of India

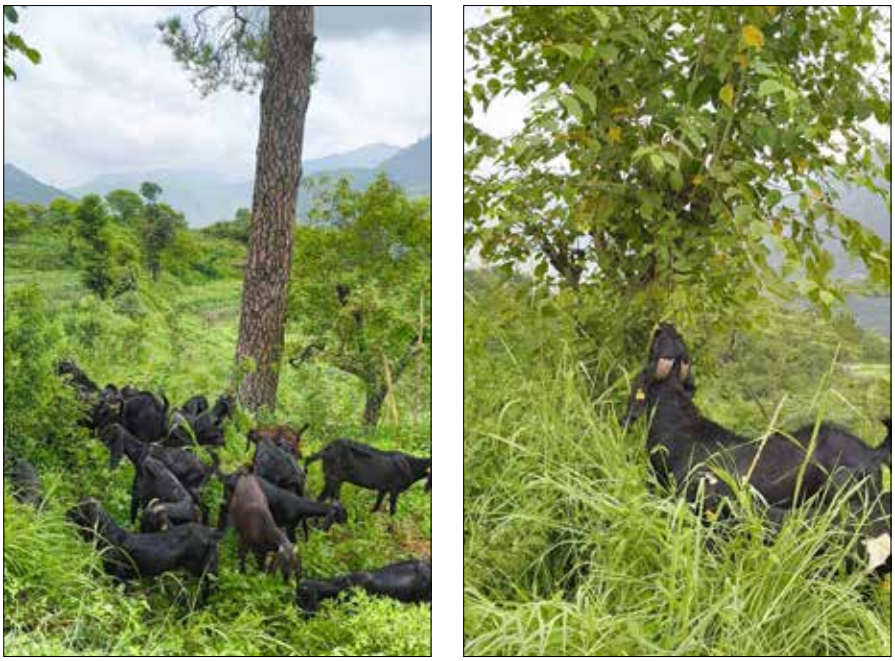
Agro-climatic zone	Components
Western Himalayan Region	*Grewia optiva* J.R. Drumm. ex Burret/*Morus alba* L. + *Setaria sphacelata* var. *anceps* (Stapf) Veldkamp
Eastern Himalayan Region	*Morus alba* L. + *Pennisetum purpureum* Schum./*Setaria anceps* (Stapf) Veldkamp
Lower Gangetic Plains	*Morus alba* L. + *Dicanthium annulatum* (Forssk.) Stapf, *Albizia lebbeck* L. (Benth) + *Pennisetum purpureum* Schum.
Middle Gangetic Plains	*Albizia lebbeck* L. (Benth) + *Dicanthium annulatum* (Forssk.) Stapf.
Trans-Gangetic Plains	*Bauhinia variegata* L.+ *Cenchrus ciliaris* L.
Upper Gangetic Plains	*Bauhinia variegata* L. + *Chrysopogon fulvus* (Spreng.) Chiov.
Eastern Plateau and Hills Region	*Leucaena leucocephala* (Lam.) de Wit + *Dicanthium/ Pennisetum/ Chrysopogon*
Western Plateau and Hills Region	*Acacia mangium* Willd. /*Ziziphus* + *Cenchrus ciliaris* L.
Southern Plateau and Hills Region	*Leucaena leucocephala* (Lam.) de Wit + *Stylosanthes hamata* (L.) Taub.
Eastern Coast plains and Hills region	*Artocarpus* + *Cenchrus ciliaris* L./*Pennisetum purpureum* Schum. /*Chrysopogon fulvus* (Spreng.) Chiov.
Western Coast Plains and Ghats Region	*Hardwickia binata* Roxb. + *Cenchrus ciliaris* L.
Gujarat Plains and Hills Regions	*Leucaena leucocephala* (Lam.) de Wit / *Ailanthus excelsa* Roxb. + *Cenchrus ciliaris* L.
Western Dry Region	*Albizia lebbeck* L. (Benth) /*Ailanthus excelsa* Roxb. /*Prosopis cineraria* (L.) Druce + *Cenchrus ciliaris* L. /*Panicum antidotale* Retz.
The Island Regions	*Bauhinia variegata* L. + *Cenchrus ciliaris* L., *Erythrina variegata* L. + *Pennisetum purpureum* Schum.

Source: Dhyani *et al.* (2009), Jinger *et al.* (2023), Singh *et al.* (2024).

These systems also perform well under harsh climatic conditions, where they are able to generate comparatively better productivity and returns despite environmental constraints. Trees play a key role in two- or three-tier silvipastoral systems, offering several advantages over herbaceous plants. Their advantages include:

- Access of deeper soil nutrients and using water more efficiently through their deep roots.
- Provide green forage during dry seasons.
- Supply fodder during scarcity, such as floods and droughts.
- Offer shade to animals during the hot summer months.

Forages constitute a fundamental component of



Goats grazing in Himalayan silvipastoral systems

Table 4. Crude protein content and forage harvest of different species used in Silvipastoral systems

	Species name	Crude protein (%)	Forage harvest (Green fodder yield/annum)
Tree species	*Acacia catechu* (L.f.) Wild	10.87	12–18 kg/tree
	Acacia nilotica (L.) Willd. ex Delile.	12–18	12–20 kg/tree
	Albizia lebbeck L. (Benth)	18–22	10–15 kg/tree
	Albizia chinensis (Osbeck) Merr.	13.56	13–15 kg/tree
	Bauhinia variegata L.	10.7–15.9	18–22 kg/tree
	Grewia optiva J.R. Drumm. ex Burret	17.6–18.67	12–18 kg/tree
	Gliricidia sepium (Jacq.) Kunth	18–25	6–10 kg/tree
	Leuceana leucocephala (Lam.) de Wit	21.19	15–20 kg/tree
	Morus alba L.	15–22	12–18 kg/tree
	Prosopis cineraria (L.) Druce	13.9–15.3	25–30 kg/tree
Grass species	*Brachiaria* spp.	12–16	40–60 t/ha
	Cenchrus ciliaris L.	8–14	40–70 t/ha
	Chrysopogon fulvus (Spreng.) Chiov.	5.50–15	15–30 t/ha
	Dichanthium annulatum (Forssk.) Stapf.	10–14	30–70 t/ha
	Panicum maximum Jacq.	12–18	250–350 t/ha
	Panicum antidotale Retz.	4.00–15.6	10–35 t/ha
	Paspalum dilatatum Poir	10–15	39–65 t/ha
	Pennisetum purpureum Schumach.	10–16	150–250 t/ha
	Pennisetum polystachion (L.) Schult.	6.50–12.3	5.0–8.2 t/ha
	Setaria sphacelata (Schum.) Stapf & Hubb.	4.60–11.5	25–40 t/ha
Shrub species	*Berberis aristata* DC.	18.06	1–1.5 kg/plant
	Boehmeria virgata (G. Forst.) Guill.	17.20	5–6 kg/plant
	Cajanus cajan (L.) Huth	18–24	2–3.5 kg/plant
	Calliandra calothyrsus Meisn.	15–22	5–10 kg/plant
	Carissa spinarum L.	18.95	350–450 g/plant
	Desmanthus virgatus (L.) Willd.	17–22	5–7 kg/plant
	Sesbania sesban (L.) Merr.	20–28	6–15 kg/plant

Source: Dwivedi (1992), Singh and Makkar (2002), Mandal *et al.* (2005), Shelton and Dalzell (2007), Bhatta *et al.* (2012), Brown *et al.* (2016), Mishra *et al*. (2020), Katoch (2022), Som *et al.* (2024), Sharma *et al.* (2025).

livestock diets, serving as an economical and nutrient-rich feed resource. However, during the lean period of green fodder availability, particularly from October to March, farmers experience a pronounced scarcity of fresh forages for livestock feeding. To bridge this gap and fulfill both the feed and nutritional demands of their animals, farmers largely rely on available tree fodder. Tree foliage serves as a crucial feed resource during the lean season, addressing both the nutritional and overall feed requirements of livestock. Owing to its richness in protein and other essential nutrients, tree foliage plays a vital role in supporting livestock health, productivity, and sustainable feeding systems.

SUMMARY

The promotion and expansion of silvipastoral systems in goat farming presents a sustainable and ecologically viable approach in addressing fodder scarcity, improving livestock productivity, and enhancing soil health. The synergistic interaction between multipurpose tree species and forage crops ensures a continuous supply of quality foodder, leading to improved growth performance, milk yield, and overall animal health. Additionally, silvipastoral practices contribute significantly to carbon sequestration, soil fertility enhancement, and biodiversity conservation, making them a promising climate-resilient strategy for sustainable livestock production. Empirical evidence suggests that adopting well-planned silvipastoral models not only improves farmers' economic returns but also strengthens the resilience of traditional agroforestry landscapes. The optimised nutrient dynamics and diversified land use associated with these systems make them a crucial component of regenerative agriculture in different agro-climatic regions of India. Implementing silvipastoral systems and restoring degraded pastures can significantly improve productivity, ensuring economic and ecological sustainability in goat farming.

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