Forage and Fodder Development on Rangelands of the Indian Himalayas

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Introduction

The Himalayas are one of the greatest geographical entities on earth. This diverse mountain range extends over 3,200km from east to west. In the east, the Himalayas begin from the southward bend of the Brahamputra River, extending to the Indus river to the west of Nanga Parbat. Though the width of this mountain system varies at different points, it extends over an axis from the Indo-Gangetic plains to the Kunlun mountains in China. It is believed that the Himalayan system is not restricted to the Indian sub-continent but actually extends further into the European Alpines through the Hindu Kush and the Caucasus (Mani 1994).

The Himalayas have been described as the 'saviour' of the Indian subcontinent. The northern parts of the sub-continent lie along the Tropic of Cancer and, climatically, should be a desert. Due to the Himalayas' influence on temperature and precipitation, however, this area's climate is mild and highly productive. The Himalayas also give rise to monsoon rains. The origin and trajectory of a number of perennial rivers are the major water sources for a large number of people living in India's mountains and adjoining plains.

The Himalayas also support an enormously diverse resource base. However, in recent years the unsystematic overexploitation of these resources has created vast environmental imbalances, disturbing fragile ecosystems and causing ecological degradation, throughout the Himalayan region, including India's rangelands.

Present Status of Forage and Fodder Resources

Animal husbandry is the most important pursuit of India's Himalayan communities. Pastoralism was introduced into these areas centuries ago by Aryan settlers. Gradually, terrace farming came into being and the net area of pastures and other grazing lands began to decline. In many Himalayan communities, climatic constraints only allow farmers to grow a single crop per year. The agricultural products yielded from this one harvest are almost exclusively used for human consumption. Forage cultivation is the farmer's last priority. They have historically depended on free ranges to feed their animals. Such pasture still provides most of the herbage required for raising livestock; crop residues, aquatic vegetation, and tree fodder supplement grasslands and help meet livestock nutritional needs. The lack of cultivated forage and the decline in pasture productivity, however, has resulted in critically low livestock biomass throughout the entire Himalayas.

Eastern Himalayas

The eastern Himalayan region is comprised of nine states: Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura, and the hilly regions of West Bengal. Out of the total geographic area of 275,000 sq. km., 212,000 sq. km. are located in the hills where arable agriculture is not possible. Agricultural activity is mostly confined to valley basins, plains, and terraced foothills. Thick rain forests cover 63 per cent of the eastern Himalayas. Areas of *jhum* or shifting cultivation occupy about 35 per cent of the hills.

According to one estimate, the east Himalayan states require 22.8 million tonnes of green fodder per year to maintain optimum feeding levels; available fodder meets less than half of this need (Chatterjee and Maiti 1988). Livestock graze on free ranges in forest areas. This activity, over time, has caused heavy forest degradation. Available crop residues exist in inadequate quantities to supplement free grazing. From October to March, forest vegetation dries up. Animal nutritional requirements, particularly for lactating animals, cannot be met by grazing alone.

Native fodder trees are another major source of livestock forage. Rations are substantially supplemented with fodder from trees like *Acer, Aescuwus, Albizzia, Anogeissus, Ailanthus, Bauhinia, Betula, Cedrala, Dalbergia , Erythrina, Ficus, Grewia, Puercus, Ulmus,* and so on. Grasses found in forests at this time are nutritionally poor and may contain only 2-18 per cent of crude protein (Verma 1988). Nevertheless, this is the most common source of fibre and is often collected by pastoralists. On the contrary, high altitude herbage is very nutritious and may contain 17 per cent crude protein.

Central Himalayas

The Central Himalayas is comprised of the Kumaun and Gharwal regions of Uttar Pradesh and occupies an area of 5.15 million hectares. Eighty per cent of the hill population is engaged in agriculture or livestock-rearing. These occupations are complementary to each other, as arable agricultural systems require draught animals for farm labour. Domesticated animals are reared according to sedentary, semi-migatory, or migratory pasture management systems. Fodder cultivation is confined to the outer hills — areas in which a farmer may be able to spare some of his land for forage cultivation. In the middle and higher hills, fodder cultivation is negligible. Livestock graze on sub-Alpine and Alpine pastures during summer and are stall-fed on crop residues during winter. Grassland vegetation in the middle hills is poor becuase of the area's ecology and has been further degraded due to intense grazing pressure. Such pressures have also encouraged soil erosion at a rate of 0.8-1.7 mm per year in the Kumaun Hills (Bartarya and Valdiya 1988).

The total annual fodder availability in the central Himalayas is 8.3 million tonnes (Table 1). Yet the total annual requirement is 22.4 million tonnes (Singh 1995). This huge gap between actual and required fodder levels has led to considerable decline in livestock productivity, thereby questioning the sustainability of local animal husbandry and pastoral management systems. A number of pastoral communities inhabits this area, among whom the *Kumauni*(s), *Jadha*(s), *Marchya*(s), *Kha*(s), *Bhotia*(s), *and Khadwal*(s) are the most common. These pastoralists migrate both horizontally and vertically throughout these areas with their herds. Lack of adequate fodder and healthy pasture is threatening the maintenance of such lifestyles.

Table 1: Biomass Availability and Nutritive Value of Sub-Alphine and Alpine Pastures

Site	Altitude (m)	Green fodder (t/ha)	Dry matter (t/ha)	Crude protein (t/ha)
Himachal Pradesh				
Nurpur	500	20.4	5.1	4.5
Hamirpur	675	20.0	5.0	4.1
Simtoli	1000	15.4	4.8	5.5
Holta	1345	17.8	4.7	5.1
Bundla	1675	13.4	4.9	6.8
Mashobra	2360	8.7	2.9	6.1
Chharabra	2685	8.8	2.5	7.1
Kufri	2915	9.3	2.9	8.9
Kaylong	3515	18.6	5.1	9.8
Jammu and Kashmir				
Dachigam	1900	20.5	6.15	-
Gaobal	2000	10.8	2.7	-
Duksum	2500	29.1	9.3	-
Kralpathri	2500	14.6	3.6	-
Gaomarg	3000	14.7	3.6	-
Drobmarg	3200	10.8	2.1	-
Dagwan	3400	14.0	4.2	-
Uttar Pradesh				
Nainital	1350	28.3	7.2	-
Almora	1550	15.7	4.5	6.5
Sunderdhung	3200	29.3	8.2	-
Gordon	3600	22.6	7.3	9.8
Tungnath	3200-3700	1.6	0.32	-
Baideni Ali	3300-4000	2.5	0.57	-
Rudranath	3250-4200	3.9	1.01	-
Panwalihanthe	3800-4000	2.2	0.44	-

Northwestern Himalayas

The states of Jammu and Kashmir (J&K) and Himachal Pradesh (H.P.) comprise the northwestern Indian Himalayas. This area exhibits a tremendous diversity in topography, climate, soil types, vegetation, and farming practices. The outer hills or 'Siwaliks' support scrub vegetation and the climate is subtropical with harsh summers. The middle hills are the true temperate regions and support predominantly temperate vegetation. Agricultural activity only occurs below 2,000 metres, after which land becomes agriculturally unproductive and rugged. Given these conditions, livestock rearing plays a major role in the local socio-economy. Above the middle Himalayas lie the cold, arid deserts of Lahul, Spiti, and Ladakh. The total area of the J&K state is 138,124 sq. km., of which 4,164 sq. km. is classified as pasture/grazing land. Himachal Pradesh's total area of 145, 000 sq. km. includes 55,600 sq. km. of pastureland.

Complex transhumant grazing systems pervade in these areas and are a means of supplying domestic livestock with enough fodder to survive and be productive. Generally, pastoralists and their herds migrate from the plains and outer hills to alpine areas during the summer, returning to the plains during winter when high pastures are covered with snow. In the entire temperate region, cultivation only occurs from April to September. Winters are harsh. Due to snow cover, it is not always possible to pro-

duce a winter crop, even at significantly lower altitudes. As land holdings are very small, farmers tend to only propagate food crops. Fodder is not cultivated at all in the temperate zone, although it is sometimes grown in small quantities at lower altitude temperate regions.

Forest areas and community sub-Alpine and Alpine pastures are the major source of area fodder. These pastures are known by a variety of names throughout the north-western Himalayas. Called *Marg(s)*, *Bahak(s)* or *Dhok(s)* in the J&K regions, such grasslands are known as *Thach* or *Bhugiyals* in H.P. Alpine and sub-Alpine pastures are used by semi-migratory and migratory herders throughout the summer. Under the semi-migratory system, villagers living around 2,000 metres hire a few herders *(chaupan)* who gather village animals and take them to area pastures while animal owners harvest rice husks and dry them for hay. In autumn, fodder trees, such as *Celix, Celtis, Robinia* etc, are lopped and tree leaves are stored for animal consumption during winter. Crop residues (primarily paddy straw) are stacked indoors, generally in the attics of houses, and used as supplementary winter fodder.

Cold-Arid Deserts

The cold arid deserts lie above the middle Himalayas in the Greater Himalayan system and are unique biological entities. This complex geography of large valleys, high mountains, and elaborate plateaus encompasses Ladakh and Lahul Spiti. Both precipitation and vegetation cover are low, the latter not exceeding five per cent of the total area (Misri 1988). Agricultural land is limited to the cultivation of *alfalfa*, naked barley, wheat, buckwheat, and some millet on the banks of lower altitude rivers near Kargil and Leh. The winters are very severe here. In January, temperatures may drop to -40°C. Yet animal husbandry pervades local livelihood systems and is practised up to 5,200 metres (Misri 1994).

Medicago sativa and *M. falcata* are extensively cultivated on small landholdings during summer. Traditionally, farmers only cut crops for fodder once, drying this hay and using it for their livestock during winter. Crop residues are also used extensively to supplement free-range fodder. At areas above 4,000 metres where nomads rear *Pashmina* goats, the herbage production ranges between 12.0 - 18.7 t/ha on area pastures during summer and fall, and becomes more bleak as winter moves in (Misri 1994). The situation gets worse during winter. These grazing areas are treeless and the bushy vegetation is either too thorny or too noxious to be grazed. About 50 species of edible grasses and legumes are found in such regions, but their frequency of occurrence is very low (Misri 1982).

Forage Resource Improvement Prospects

Forage availability throughout the Himalayas is, generally speaking, quite poor. However, research on these topics has been carried out at the Indian Grassland and Fodder Research Institute's Regional Centre in Srinagar, Kashmir, as well as at other research institutions and universities. The results of these investigations have provided answers for most of the existing problems. If the recommendations indicated by such studies are adopted by farmers, pastoralists, and development agencies, the Himalayas could become a highly productive region for livestock.

The improvement of forage resources in the Himalayas implies a simultaneous development of both pastures and cultivated fodder, as both of these resources are used

continuously or sequentially across the spectrum of animal husbandry systems. Proposed scientific interventions are listed below.

Pastures

Pastures in the Indian Himalayas are in urgent need of improvement, both in terms of management and quality control. Migration patterns should be shifted to increase time for pastures to regenerate. Drilling or dabbling seeds in existing pastures during the fall has been a successful means of improving free-range fodder and should be encouraged (Misri 1988). Productive species of grass for all regions of the Himalayas have been identified (Singh 1995; Sood *et al.* 1995; and Misri 1988). Proper pasture management would require regular monitoring of pasture health, as well as fertilizer application and resowing, wherever necessary. Before resowing is started, however, it is essential to improve forage resources along migration routes, thereby delaying the arrival of livestock by 30-45 days. This time period will be sufficient for new seedlings to establish themselves. An adequate quantity of legumes (50%) should be sown on pastures to control weeds (Misri 1988).

Pastures and other grazing lands at lower elevations of the lower and middle hills can also be improved in order to substantially increase forage resources. By the adoption of agri-silvipastoral systems in lower altitudes of the eastern Himalayas, financial returns can reach Rs 48,960 per hectare (Anonymous 1984; see Table 2.) Similarly, by adopting proposed scientific interventions to develop forage resources on different kinds of wastelands, production can be increased to up to 72 t/ha (Table 3).

Most farmers in the lower hills enclose their grasslands and harvest grass at the onset of winter when grasses are almost dry. Yet these grasslands should be harvested earlier when vegetation is nutritious and palatable. Such areas should also be fertilized with nitrogen (80 kg/ha). This application can increase production from 1.04 to 1.96 t/ha (Table 4). If fertilizer is applied twice, production can be increased by 2.02 t/ha. Production can be further increased from

Table 2: **Economics of Microshed Based Forage Production Systems in the Eastern Himalayas**

Economic parameters (Rs/ha)	Dairy farming	Agro-pastoral system	Agri-horti-silvipasture system
1990-91			
Input	23,184	29,675	10,604
Output	37,384	50,882	20,943
Net returns	14,200	21,207	10,339
1993-94			
Input			
- with livestock	45,030	38,201	11,406
- without livestock	-	17,366	9,197
Output			
- with livestock	93,992	78,692	24,468
- without livestock	-	31,942	13,120
Net returns			
- with livestock	48,960	40,490	13,061
- without livestock	-	14,575	3,922

Source: Anonymous (1984-94)

Table 3: Forage Production Potential from Different Land-use Systems in the Low and Middle Hills of the Eastern Himalayas

	Land Use	Forage production system	Green forage yield (t/ha)
1	Permanaent pastures/ wastelands/ degraded lands	Silvi-pasture grassland	15.6-51.6 42.1-74.6
2	Current fallow	Seasonal forage crops	25.0-54.0
3	Alternative land, i.e., terrace risers/terrace bunds	Perennial grasses and legumes stylos Fodder trees grasses	40.4-60.0 2.8-5.0 5.7-8.3 c/1000 rm
4	Horti-pasture	Seasonal forage crops/ perennial grasses and legumes	12.5-15.7
5	Watersheds	Perennial grasses	40.0-65.0
6	Dairy farms in watersheds	Silvi-pasture	3.7-72.0
7	Bamboo plantations	Orchard, Nandi, Deenanath grass and Stylo	3.3-38.3

Source: Singh et al. 1993

Table 4: Effect of Fertilizer Management on the Productivity of Mid-Hill Grassland in the Central Himalayas

Treatment	Fresh forage yield (t/ha)
Fertilizer application (N kg/ha)	
- 0	1.04
- 40	1.52
- 80	1.96
N application pattern	
- Basal	1.47
- Two splits	2.02

Source: Singh, V 1995

Table 5: Effect of Fertilizer Application on the Green Herbage Production of Natural Grasslands in the Central Himalayas (t/ha)

Nitrogen	Phosphorus			Average
	P_0	P_{30}	P_{60}	
N_0	1.77	2.31	3.22	2.43
N_{30}	3.42	4.27	5.26	4.32
N_{60}	4.69	5.51	7.02	5.74

Source: Melkania 1995

Table 6: Yield Potential of Established Grasslands in the Middle Hills of the Central Himalayas

Grassland type	One cut/yr green T/ha	Two cuts/yr green T/ha
Panicum coloratum	50.62	53.29
Digitaria sp	25.76	35.97
D. decumbens	26.64	33.21
Brachiaria mutica	39.08	28.41
Cynodon plectostachys	19.54	21.76
Panicum repens	32.86	20.41
Chloris gayana	15.10	13.10

Souce: Melkania and Tandon 1989

1.77 to 7.02 t/ha by applying 60 kg/ha of both nitrogen and phosporous (Table 5).

Wastelands can be turned into very productive ranges by introducing and establishing new species. Yield potentials of various species have been documented by Melkania and Tandon (1989) and are presented in Table 6. Between 13.10 and 53.29 t/ha, fresh fodder can be obtained from these wastelands. Similarly, studies of the introduction of pigeon peas on natural grasslands (Sharma and Sood 1994) indicate that green fodder yields decrease slightly from 10.4 to 9.6 t/ha, while dry matter yields increase from 3.1 to 3.2 t/ha with the addition of 0.62 t/ha of local pigeon peas (Table 7).

Table 7: Yield Increase in a Natural Grassland by the Introduction of a Food Crop in the Western Himalayas (average: 3 years)

System	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	Grain yield (t/ha)
Natural grassland	10.4	3.1	-
Natural grassland + pigeon pea	9.6	3.2	0.62

Source: Sharma and Sood 1994

Forage Crops

A number of intensive forage production rotations yielding year-round fodder has been established (Table 8). These rotations can provide 79.2 to 129.9 t/ha of green matter and 15.3 to 25.3 t/ha of dry matter. The economic returns from these rotations range between Rs 14,754 and Rs 26,995. Similarly, by growing berseem, oats, or these two crops in combination and on a rotational basis with *Kharif* crops, crops can yield 52.8 - 89.2 t/ha green forage and 12.0 - 17.5 t/ha dry matter, while protein yields range between 1.75 - 270 t/ha (Table 9). Production can be greatly increased by scientifically managing a *Kharif* crop such as maize, grain, green forage, and stover. Traditional maize cultivation systems, however, provide only 4.6 t/ha of grain and 9.8 t/ha of stover. With the application of nitrogen fertilizers, a green forage cut can be imposed 60 or 75 days after sowing; later, the crop can be harvested for grain. Nitrogen application also maintains stover availability (Table 10). Similar findings have been found in relation to a number of other crops like *Sorghum, Pennisetum, Cowpea,* etc. Tremendous potential exists throughout the entire Himalayan belt for the cultivation of forage; but farmers must be motivated to integrate forage production into present cropping systems.

Table 9: Forage and Crude Protein Yield under Intensive Forage Production in the Western Himalayas

Crop	Fodder yield (t/ha)		Crude protein yield (t/ha)
	Fresh	Dry	
Berseem	58.6	12.0	2.32
Oat	52.8	12.9	1.75
Oat + Berseem	89.2	17.5	2.70

Source: Sood and Dahal 1993

Alternative Land Use for Forage Cultivation

In India's hill areas, shortages of cultivable land always limit fodder production potential. Efforts have been made to grow fodder on land such as the barren spaces between orchards. These are excellent sites for forage production — particularly in re-

Table 8: Forage Yield and Economics of Different Intensive Forage Crop Rotations in the Western Himalayas (average: 5 years)

Crop rotation	Forage yield (t/ha)		Economic returns (Rs/ha)
	Fresh	Dry	
Maize + Cowpea - Berseem + Oat	94.2	20.1	18,252
Teosinte + Velvet bean + Oat + Peas	79.2	15.3	14,754
NB Hybrid + Velvet bean – Berseem + Mustard	129.9	25.3	26,995
NB Hybrid - Turnip - Oat + Vetch	86.1	17.4	15,212
Setaria + Soyabean – Berseem	83.6	17.8	17,778
Maize + Velvet bean - Lucerne + Berseem	85.4	15.8	16,537
Sorghum + Cowpea - Berseem + Mustard	86.3	17.8	17,124

Source: Sood and Bhandari 1987

Table 10: **Grain, Fresh Fodder, and Stover Yield of the Maize Crop System in the Western Himalayas**

Treatment	Grain yield	Fresh fodder yield (t/ha)	Stover yield
Nitrogen application (kg/ha)			
90	3.4	18.9	8.8
112	3.9	21.2	9.5
135	4.2	22.6	9.9
Harvesting stages			
60 DAS	3.8	18.9	9.4
75 DAS	3.2	22.9	9.0
Traditional System	4.6	-	9.8

Source: Sood 1991

gions where cultivable land is in short supply. Green forage yields can reach 1.148 t/ha by planting various perennial grasses and legumes in orchards (Tables 11 and 12). Terrace risers occupy a lot of space in hill farming. Up to 15.04 t/ha of forage can be produced on these sites with active cultivation efforts. Under natural conditions, these terraces provide only 1.23 t/ha of biomass (Table 13).

Table 11: **Fodder Production Under Horti-pasture System in the Western Himalayas**

System	Green forage yield (t/ha)
Orchard grass + Red clover	42
Rye grass + Red clover	48
Brome grass + Red clover	39
Timothy + Sub clover	35
Fescne	6.7
Orchard	3.1
Rye	2.1
Natural vegetation	1.1

Source: Misri 1986, Sharma and Jindal 1989

Table 12: **Production Potential of Hortipasture in the Central Himalayas (Apple Orchards)**

Pasture sp	Green forage yield (t/ha)
Red clover	2.6
White clover	2.4
Lucerne	2.5
Perennieal rye grass	3.1
Orchard grass	2.7
Canary grass	2.1
Barren orchards	1.8

Source: Singh 1995

Table 13: **Terrace Risers: A Potential Site for Forage Production in the Central Himalayas**

Species planted on terrace risers	Grain yield t/ha)		Forage yield (t/ha)
	Rice	Wheat	
Nandi grass	1.04	1.14	10.8
Guinea grass	1.01	1.16	10.3
Hybrid napier	1.08	1.21	15.04
Rhode grass	0.98	1.04	9.88
Indian couch grass	0.85	1.02	8.62
Natural vegetation	0.56	0.98	1.23

Source: Bhatnagar and Kundu 1992

Hill farmers generally believe that nothing can be grown under the canopy of coniferous trees. Studies undertaken in Almora, however, suggest that various forage species can be grown under both pine and deodar trees providing green forage yields between 14.0 and 13.66 t/ha, respectively (Table 14). Fallow winter lands are another potential source of land for forage cultivation. Green forage yields up to 69 t/ha can be obtained from these areas (Table 15).

Conclusion

The ecology and agricultural potential in the Indian Himalayas are unique onto themselves. Natural factors, such as altitude, cli-

Table 14: Yield Performance of Perennial Grasses Grown under Coniferous Tree Canopy in the Western Himalayas

Grass species	Green forage yield (t/ha)	
	Pine trees	Deodar trees
Pangola	14.01	13.66
Rhodes	4.78	3.06
Para	0.4	2.06
Guinea	0.41	2.04
Kikyu	-	6.42
Natural veg.	0.25	0.22

Source: Koranne and Singh 1989

Table 15: Forage Production Potential of Winter Fodder Crops in the Westen Himalayas

Crop	Fertilizer requirements (kg/ha)	Green forage yield (t/ha)
Berseem	90 P	50
Triticale	90 N	37
Vetch	120	45
Barley	90	35
Oats	90	52
Turnips	60 N + 60 P	69

Source: Misri 1988

mate, soil, and others, are dynamic throughout the entire Himalayan system, thereby affecting production and sustainability of agricultural systems. Pastures, particularly in sub-Alpine and Alpine regions, are areas of climatic climax. Production in these areas can be sustainable only if management and overall rangeland quality are improved. Efficient grazing systems should be established. Areas should be constantly monitored and maintained. Appropriate stocking rates should be determined. Herd size could be reduced substantially if the forage resource base at lower altitudes is strengthened, thereby making individual animals more productive.

Technologies for achieving higher biomass from natural and cultivated forage resources are available in India and should be adopted by communities living in the Indian Himalayas. In order to facilitate the adoption of such technologies and further increase forage production levels, suitable grazing systems need to be developed. Appropriate grass-legume mixtures should be determined and a variety of high-yielding trees and bushes should be introduced. Likewise, improved varieties of pasture and grass species should be bred. Technology transfers and on-farm adaptive trials should be executed. Adequate quality grass and legume seed should be produced and made available to local people. Finally, the socioeconomic components of India's pastoralists should be studied, understood, and incorporated into development programmes.

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