Status of Himalayan Rangelands in India and Their Sustainable Management

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Introduction

India's climate, topography, flora, fauna, and land-use patterns are very diverse. Precipitation ranges from the lowest to the highest levels on earth. Altitudes vary from sea level to some of the highest peaks in the world. Temperatures range from sub-zero in the Himalayas to about 50°C in the central and western areas of the country.

India's diversity of environments has given rise to a spectrum of rangeland ecologies. Domestic animal husbandry remains a constant theme throughout India's diverse ranges. Rich grassland resources have sustained livestock very efficiently for centuries; however, the gradual increase in human population and related development activities, as well as the subsequent increase in livestock numbers and natural forces, such as soil erosion, has upset the balance of India's rangeland environments. Twelve million hectares of permanent pasture have been converted into wastelands with very meagre production.

Rangelands are not the only source of fodder for area livestock. Hill slopes, forests, and wastelands, as well as cultivated fodder resources, crop residues, and feed concentrates, all help meet the nutritional needs of India's livestock. Yet, in environments in which livestock depend entirely on grasslands, fodder availability is often low. The shortage and misuse of rangelands is critical. Without increasing the production levels of these resources, achieving optimum - or at least improved - levels of animal biomass remains impossible.

Background and Present Status

India's rangelands cover an area of about 121 million hectares, approximately 40 per cent of the country's geographical area, and are used in a variety of ways. Sedentary, semi-migratory, and migratory systems of grazing are all found throughout India. Due to extremities of climate, poor management, and constant grazing, these areas have degraded at an alarming rate. Some rangelands are becoming less productive than other well-managed grasslands, providing animals with less herbage and nutritional requirements. Yet, all of these ranges remain vital for rearing domestic animals.

In the Indian Himalayas, alpine grasses and meadows account for 114,250 sq. km. Permanent pastures and grasslands cover 123,000 hectares in Jammu and Kashmir, 158,000 hectares in Himachal Pradesh, and 299,000 hectares in Uttar Pradesh. These pastures and grasslands range from 300 to 4,500 masl, traversing sub-tropical, temperate, and alpine environments.

The change from subtropical to temperate conditions occurs around 1,800 metres. Both subtropical and temperate grasses occur at this altitude. These pastures are characterised by cool summers (15-20°C), followed by heavy monsoon rains (1,000-2,000mm) and cold winters (-8 to 8°C) with heavy snowfall (2-5m). The common sub-tropical species found in these areas are: *Arundinella setosa, Themeda anathera, Pennisetum orientala, Chrysopogon gryllus, C fullus, Apluda mutica, Heteropogon contortus,* and *Dichanthium annulatum*. Temperate species include *Deyeuxia scabrescena, Stipa spp, Poa pratensis, Festuca kashmiriana, Agropyron longe-aristatum,* and *A. semicostatum*. Subtropical grasses disappear around 2,650 metres and temperate types predominate. Common temperate genera include: *Deyeuxia, Helictotrichon, Brachypodium, Bromus, Dactylis, Festuca*, and *Trifolium*.

According to edaphic and microclimatic conditions, these temperate pastures can be categorised as dry rangelands (1,800-2,400m), humid rangelands (2,400-3,200m), semi-arid and arid rangelands in the inner Himalayas (2,800-3,200m), and sub-alpine and alpine pastures (above 3,200m). These different zones have distinct climatic conditions and different edaphic problems, requiring grass species and genotypes specifically suitable for each zone.

In the northwestern part of India, the high altitude sub-alpine and alpine pastures are grazed during the short summer by migratory herds who depend on other grazing resources the rest of the year — a period as long as eight months. Rangelands only cover 5.4 per cent and 3.5 per cent of Rajasthan and Gujarat, respectively. Yet these western regions maintain high livestock productivity levels as a result of alternative and supplementary grasslands. In the east, grasslands and pastures comprise less than one per cent of the total area, even though animal husbandry is an important source of livelihood for local people.

Singh and Misri (1993) determined that India's region with the highest rangeland carrying capacity is Kerala, where 1.47 adult cattle units (ACU) can be reared per hectare of grassland. India's grassland carrying capacity is lowest in Haryana, where only 0.20 ACU can be sustained per hectare of range. In semi-arid areas, grazing intensity ranges from 1.04 to 51.08 ACU per hectare (Shankar and Gupta 1992). In arid areas, grazing capacity is only 0.2 to 0.5 ACU ha^{-1} (Raheja 1966) — a situation mirrored throughout much of the country.

The increase of grazing pressure due to rising human and livestock populations, terrain, scanty vegetation cover, extremities of climate, erratic rainfall, constant neglect, and an ever-increasing livestock and human population have rendered India's grassland ecosystems fragile. Edible species have been replaced by noxious weeds. Plant regeneration levels remain low, leading to scanty vegetation cover which precipitates tremendous soil erosion and water loss. This degradation has occurred to such an extent that now the once productive grasslands are classified as wastelands. Gupta and Ambasht (1979) classified 80 per cent of the grasslands as 'poor'. Only an integrated approach to conservation can correct this situation. Proper stocking rates and management practices will help India's grasslands regain their ecological balance and also improve animal productivity.

Challenges

Various estimates have been made about the demand and supply of fodder throughout the country. Singh (1988) estimated that, by 2000 AD, India may require 822 tonnes of dry matter per year to maintain its animals. In order to increase productivity, at least 1,253 tonnes of dry matter will be required per year. Shankar and Gupta (1992) estimated that India is short of 69MT of dry forage annually. In addition to forage provided by rangelands, these areas produce fuel, timber, and other minor forest products. It is estimated that India is losing 1.5 million hectares of forest land every year due to various processes of degradation; yet 68 per cent of the rural and 45 per cent of the urban populations use wood as fuel (Qazi 1994). Fuel demands and the need for fodder production must be met from the same eco-regions. As such, it is necessary to reconsider how these rangelands are managed.

In addition to grassland herbage, agro-wastes play an important role in augmenting roughage supply. The animal pressure on one hectare of land providing agro-wastes ranges from 0.75 to 16.80 megatons; the demand for cultivated fodder is equally high. The states of Gujarat, Haryana, Punjab, and Rajasthan have started to cultivate fodder. However the animal pressure on one hectare of land that includes such fodder crops is 19.78, 11.07, 12.90, and 15.95, in these states, respectively (Singh and Misri 1993).

In spite of inherent limitations of animal rearing given rangeland production levels, the availability of animal products has increased considerably during the past few years. This demand will continue to rise in the future as human populations grow. Yet biomass production must be increased to balance animal product supply and demand. Likewise, grassland production must be sustainable. These are the greatest challenges facing users and researchers of India's rangelands.

Sustainable Rangeland Management

In the hills of India, farmer prosperity depends on animal husbandry, horticulture, and forestry; other sources of income are limited. Subsistence agriculture based on cereal and pulse cultivation is practised on about 10 per cent of the total geographical area, whereas rangelands and forests comprise 50-70 per cent of the entire region. These rangelands are the backbone of the hill farm economy and are fundamental to the rearing of sheep, goats, rabbits, cattle, and other animals for meat, milk, wool, hide, skin, and draught power. Medicinal plants are also harvested from local grasslands for profit.

The natural resources of the Himalayas have been haphazardly exploited for centuries. Reckless tree felling, overgrazing, and an absence of rehabilitation programmes have given rise to denuded hill slopes and rangelands, among other problems. Local hydroelectric projects, for instance, have often caused such degredation, resulting in flash floods and the heavy silting of reservoirs. The basic aim of sustainable rangeland management is to use the available biotic and abiotic resources, soil nutrients, and natural flora in a particular environment to produce maximum economic returns. Sustainable, scientific management of rangeland resources throughout India is needed to restore soil fertility, encourage regrowth of rare medicinal herbs and other grass species, support congenial climates for biological life, provide gainful employment to farmers, and improve the overall ecosystem.

Research undertaken on various aspects of grazing lands, animal husbandry systems, and the restoration of wastelands throughout India has generated methods and technologies aimed at restoring, regenerating, and improving area biomass production. Soil working, reseeding, fencing, and bush clearing are all sound methods of sustainable development. Rotational grazing systems, as well as water and soil conservation, destocking, and fertilizer application programmes, should be implemented. Similarly, legumes, trees, and bushes for fodder should be introduced. All of these suggestions are elements of sustainable rangeland management and are geared towards correcting the environmental imbalances afflicting India's grassland resources.

Introduction of Grass and Legume Species

<u>Dry Rangelands</u>

Dry rangeland areas consist of mixed sub-tropical and temperate vegetation. Heavy grazing pressure combined with water stress in the rhizosphere throughout most of the year and subsequent soil erosion have led to extreme degradation of these grasslands. White clover and other fine grasses do not grow well in these areas due to water stress.

In order to improve these rangelands, pasture plants with deep root systems, tolerant of drought and cold, should be planted. These types of plants can extract water and nutrients from deeper soil layers and provide good herbage yields. Suitable species include the following.

a. *Festuca arundinacea* - Hima- 1, Hima-2
b. *Trifolium pratense - UKU-5*
c. *T. ambiguum* - PCC-5
d. *Lotus corniculatus* - G-32
e. *T. repens* - PLP Comp.I

All of these cultivars meet the above criteria. *T. ambiguum,* for instance, has a strong tap root, as well as a rhizomatic root system, and binds soil well. The introduction of such cultivars in these pastures increases herbage yield by 30-40 per cent and raises quality by five to six per cent (13-14% CPDM). *Trifolium repens* is suitable for introduction into orchards. In addition to providing quality herbage, this plant fixes nitrogen in the soil at a rate of 200-300 kg per hectare.

<u>Humid Rangelands</u>

Humid rangelands are classified by temperate vegetation. A cool climate and adequate moisture in the rhizosphere help produce excellent vegetative growth. Such zones have lush, green pastures from May to September.

In order to improve rangelands in this climatic zone, high yielding grasses and legumes should be introduced into grasslands and orchards. Suitable species for this zone are as follow.

a. *Dactylis glomerara* (orchard grass) - Sumax, commet
b. *Festuca arundinacea* (Fescue grass) - Hima-2 and 3
c. *Phalaris raberosa* (Cannary grass) - Common
d. *Trifolium pratense* (Red clover) - PRC-3
e. T. *repens* (White Clover) -PWC-2,3,15, and PLP Comp.I
f. T. *ambiguum (Caucasian* clover) - PCC-5

Orchard grass can be introduced on northwest-facing wet slopes and in orchards. Hima 2 and 3 (Fescue grasses) are suitable for introduction on to drier slopes facing southeast, as well as on to field bunds and in orchards. These varieties are endophyte free and provide excellent nutritive herbage. The PRC 3 of red clover is collar rot resistant and, therefore, suitable for pastures, grasslands, and orchards. The introduction of these improved strains has been found to increase herbage yield by 60 per cent and quality by five to six per cent (14-15% CP on DM).

Semi-arid and Arid Pastures in the Inner Himalayas

The semi-arid and arid pastures in the Inner Himalayas are located in the rain shadow, receiving only 200-500mm of rain per year and one to two metres of snow in the winter. Private meadows are irrigated three to four times during the growing season (April-July) to encourage grass growth. Species found on dry hills in these areas include: *Agropyron repens, A. dentatum, A cognatum, Dactylis glomerana, Medicago falcata, Lotus corniculatus*, and *Lespediza serica*. Common temperate type grasses are found throughout irrigated meadows.

On dry hill slopes, high-yielding strains such as *Agropyron, Medicago falcata, M. sativa, Lotus corniculalus, Lespediza serica*, and *Onobrychis viccifolia* should be introduced. Improved strains such as LS 1 of *Agropyron*, Anand 3 of M. *sativa*, and LL 1 of *Lespediza serica* have been developed. They are now in advanced testing stages and their seeds are being propagated.

High-yielding multicut varieties of grasses and legumes, such as the following varieties, should be introduced into irrigated meadows.

a. *Festuca arundinacea* 'Hima I'
b. *Dactylis glomerata* 'Sumax and Commet'
c. *Trifolium pratense* 'PLP Comp.I'
d. T. *respinatum* 'SH 18'
e. *Brassica oleracea* 'Kale'

The introduction of these strains of grass in meadows has increased forage yields by 60 per cent. Peas and barley are harvested by the end of July, leaving time and scope to cultivate a fodder crop. Oats and shaftal were tried for these purposes. Shaftal cultivation was very successful. Sown by the end of July, the shaftal remained green until December, providing nutritional fodder throughout the winter. Similarly, when kale is sown as border rows in potato, pea, and hop fields, this plant remains green through December and helps supply winter fodder.

Sub-Alpine and Alpine Pastures

Sub-Alpine and Alpine pastures remain snow-bound from November to April and are open for grazing by sheep, goats, and horses from May through September. Area shepherds move rotationally according to the growth and availability of grasses. Prominent forage species found in these pastures include *Poa alpinum, Agrostis stolonifera, Festuca alpinum, Dactylis alpinum, Trifolium repens, Andropogon ishaemum, Pennisetum flaccidum, Lotus corniculatus*, and *Artemisia vulgaris*.

Soil Water Conservation

Various moisture conservation techniques can help improve herbage availability on area grasslands. Ahuja (1977) found that contour furrowing, bunding, and trenching result in herbage increases of 638, 168 and 165 per cent, respectively.

Fertilizer Management

Fertilizer application is one of the most important management options for improving biomass yield. Investigations at the Indian Grassland and Fodder Research Institute (IFGRI) revealed that the annual forage yield from natural grasslands of *Sehima nervosum*, *Heteropogon contortus*, and *Iseilema laxum* can be increased from 4.13 to 7.56, 3.47 to 5.57, and 4.49 to 6.37 t/ha-', respectively by the application of 40 kg of nitrogen per hectare (Shankar and Gupta 1922). Himalayan grassland herbage production can be increased from 1.78 t/ha to 7.01 t/ha by the application of 60 kg each of nitrogen and phosporous ha^{-1} (Sharma and Koranne 1988).

The introduction of legumes to grasslands can improve the nutritional quality of herbage and can also compensate for nitrogen application. IGFRI scientists introduced 14 different legumes in a particular grassland. The presence of these legumes enriched the soil to the same extent as would introducing 40 kg N ha^{-1}. The herbage yield increases from 3.3 to 4.0 t ha^{-1}.

Burning and Weed Management

Controlled burning and weed eradication helps increase grassland biomass. Grazing land with high bush density (1300 bushes ha^{-1}) may yield only up to 0.8 t/ha; when all bushes are eradicated, the herbage yield can increase to 4.2 t/ha (Kaul and Ganguly 1963). However, it has been recommended that 14 per cent of the area should be covered with bushes for the sustained availability of grassland herbage.

Silvipastoral Approaches

The adoption of silvipastoral systems can help people meet fodder, fuel, and timber requirements from a single unit of land. Suitable tree species have been identified by Singh (1992) according to the country's various agroclimatic regions. IGFRI determined that planting *Leucaena leucocephala* on rangelands can provide additional biomass of 20 t/ha, while *Acacia tortilis* and *Albizzia amara* increase biomass by 14.6 and 9.5 t/ha, respectively.

A five-year study (1987-91) to critically assess resource depletion and soil degradation was undertaken in three diverse agroecological niches. Bare plot, natural grassland, improved grassland, and three-tier planting systems were grazed by mixed herds of sheep, goats, and cattle according to the carrying capacity of one ACU/ha. These systems were tried on a one hectare plot and replicated four times. Results revealed that total water runoff loss was minimum from sown pasture, followed by three-tier, improved natural grassland and bare plot treatment. The average per cent of total rainfall runoff was 8.6, 9.1, 11.6, and 38.3 from sown, three-tier, improved, natural, and bare plot grasslands, respectively. Soil lost as sediment was also minimal from sown pasture — 14 times lower than from bare plot pasture.

Nutrient loss was estimated according to total soluble salt, nitrogen, potassium, and phosphorus in the runoff water collected in multisot devices after storms. The minimum total soluble nutrient loss was recorded in sown pasture. Loss of nutrients increased by about 1.5 times in three-tier, improved and natural grasslands compared to sown pasture. Bare plot nutrient losses were 3.6 - 8.3 times higher than sown pastures.

Pasture production (grass and legume) varied in different blocks at different times. The average peak production was obtained from block I (4.36 t/ha/year), followed by block IV (3.89 t/ha/ v ear) and block 111 (3.89 t/ha/year). In the fourth year, grass contributed most towards dry matter production, followed by forbs and legumes.

Data pooled over five years revealed that sown pasture produced the maximum dry matter — 11 tonnes in 1988. This number decreased to 4.4 tonnes in 1990 and 3.7 tonnes in 1991, once this land was used for grazing. Improved heteropogon-dominated natural grassland reached a maximum of about 10 tonnes in 1988, decreasing to 3.7 t/ha in 1990 and 3.1 t/ha in 1991. A similar trend was also observed on natural grasslands. When protected, yields increase up to five times, with a maximum production of 6.83 t/ha in 1989. These numbers decreased to 3.8t in 1990 and 3.7t in 1991, once the pastures were grazed. The introduction of stylo on sown pasture increased biomass by 40 per cent in 1988. However, this increase became negligable after two years of grazing, necessitating the introduction of stylo every third year to maintain production levels.

Changing Traditional Grazing Practices

Most grassland production and regeneration in the Himalayas is highly sensitive to biotic interferences such as grazing. Therefore, traditional practices such as open grazing should be changed. Rotational grazing, exclosure, and/or stall feeding, should be introduced. Simple exclosure of grasslands for two to five years can increase herbage yield as much as four times (Sharma *et al.* 1988) and heighten biodiversity three times more than continuous grazing systems. Exclosure also improved nutrient content.

Alternative Land-use System for Forage Production

In order to provide green forage year-round, alternative land-use systems should be developed on private or community lands near villages. Energy plantations, coppice farming, agroforestry, and silvipastoral land-use systems could help meet forage and fuelwood needs, conserve the environment, and help maintain soil fertility through reduced erosion and nitrogen fixation. The species of trees, shrubs, legumes, and grasses chosen for such endeavours will vary according to local needs, elevation, and climatic conditions,.

Research and Development Issues

Grassland Utilisation

Rangeland herbage should be used carefully. In established or natural grasslands, deferrment of grazing schedules helps allow vegetation to reproduce and disperse seed. Rangelands re-seeded with perennial species should not be grazed for the first year. Grazing may be permitted after seed dispersal in the second year. Grazing should not exceed the carrying capacity of the grassland (predetermined in each situation) in subsequent years. Fences are a prerequisite for the introduction of controlled grazing in most dry areas. With effective fencing, pasture yield may increase three-fold in five years.

Stocking Rates and Herd Diversification

A suitable stocking rate should be determined and strictly adhered to, according to the type and strength of a herd and available rangeland biomass. Herd diversification is another important aspect of rangeland development. An area containing both grasses and shrubs may be best used by a combination of different ruminant species with diverse grazing habits.

Ecosystem Rehabilitation

Different management systems significantly influence rangeland and livestock health through their effect on soil, water, nutrients, and biomass yield. Rangeland rehabilitation needs to be initiated, wherever necessary, by planting suitable species, managing eroded grasslands, and controlling stock numbers.

Education

The most important factor in adhering to desired rangeland management practices is the creation of a cadre of sophisticated and educated range managers. Inclusion of range management as a subject in the curriculum of various universities should be prioritised.

Economics

Flexible credit systems, which allow farmers to borrow capital from financial institutions for herd development and improvement, should be established. Long-term repayment schedules and nominal interest rates should be maintained.

Marketing

Suitable marketing networks for livestock products should be created by the government. Subsidised prices for some exchange goods might also be appropriate.

Health Care

Animal health care, either completely or partially financed by the government, should be introduced throughout livestock-rearing communities in order to increase and maintain production levels.

Fodder Cultivation

Efforts should be made to increase overall forage availability. The number of areas under fodder cultivation and agroforestry systems should be increased. This will greatly reduce rangeland pressure. The creation of fodder banks in drought-prone and other potentially dry areas should be given priority.

People's Participation

Social and cultural factors are key elements of pastoral management. Local people's participation is vital to successful rangeland systems. Prevailing management practices have to be carefully studied and blended with other improved models. Only local people can ensure the successful implementation of rangeland improvement programmes.

Research Programmes

Research programmes geared towards rangeland production, management, and utilisation should stress the following points.

- Collection, evaluation, and introduction of suitable legume species with high palatability and drought resistance
- Breeding and biotechnological programmes to create palatable, high-yielding, and stress-resistant grasses, shrubs, and fodder trees
- Evaluation studies regarding the diversification of herds to enable livestock to survive under various ecological conditions

- Extensive rangeland surveys and ecological research about different habitats
- Soil and water conservation and utilization techniques employed under various land and climatic conditions
- Role of mycorrhizae and non-symbiotic nitrogen-fixing bacteria in relation to crop and grass productivity

Policy Recommendations

The following are policy recommendations for sustainable rangeland management in India.

- Most grasslands are openly grazed. Controlling grazing is a difficult problem. Public support for keeping livestock numbers and grazing controlled would be meaningful if some alternative arrangement to meet grazing requirements could be suggested. Adequate protective measures must be provided for farmers.
- There are many legislative acts for the preservation of forests and the regulation of forest products. Vast areas are under the control of government authorities who are not fully staffed or capable of managing these areas. Long-term leasing of such areas to appropriate institutions and individuals should be encouraged.
- Development projects on wastelands/ grasslands have great potential for employment and income generation. Once these lands are more productive, the earnings of small and marginal farmers who, otherwise, live below poverty line can be increased.
- Extension related to grass and tree farming and the protection of degraded grasslands should be implemented through schools, adult education centres, and voluntary organisations. Women's participation in protecting and rearing trees is critical and should be supported.
- In any rangeland development programme, a farming systems' approach should be adopted. As scientific experiments often require social scientific inquiry, a deep understanding of local needs and perceptions should be fostered. Research should be integrated accordingly.
- Availability of adequate funds (with appropriate timing) for afforestation programmes is very important since such work is largely controlled by time and season.
- Pastoralism should be recognised as important and adequately addressed by land management policies. Rangeland should be stratified into naturally defined and ecologically distinct management units for micro-level planning and management according to environmental settings and local needs.
- Ancient local and nomadic grazing practices should be stopped. A shift to new management systems should be encouraged by improving forage availability in such areas. Herders should be educated about the harmful effects of continuous grazing. The establishment of fodder banks in surplus zones will also be an important element of forage resource development.

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