

Country Pasture/Forage Resource Profiles

INDIA



by
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1. INTRODUCTION

India, the seventh largest country in the world, lies between latitudes 8 and 37° N and longitudes 68 and 97°, and occupies a geographical area of 32.9 M km². It measures about 3 214 km from north to south and about 2 933 km from east to west. The country exhibits great diversity in climate, topography, flora, fauna and land use. The precipitation ranges from 150 mm in western and northwestern deserts to 3 126 mm in northeastern hills. The altitude varies from the coastline to the lofty, snow clad mountains of the Himalayas. The temperature ranges from subzero in the Himalaya to about 50 °C in the central and western parts. India has common borders with Afghanistan, Bangladesh, Bhutan, China, Myanmar, Nepal and Pakistan (Anon., 1997a). The population of India was estimated in July 2006 to be 1 095 351 995 with a growth rate of 1.38% (World Factbook, 2006).

Agriculture is the main occupation of the people and about 70% of the population is engaged in this activity. Livestock rearing is complementary to agriculture. The total area under cultivation is about 169.7 M ha; an additional area of 0.4 M ha is under plantation crops. Traditionally, three systems of agricultural land tenure were prevalent in India. These were *Ryotwari* (property rights held by the holder), *Mahalwari* (community proprietorship) and *Zamindari* (ownership of several villages by a single family). However, with the introduction of various agrarian reforms such as land ownership ceilings and abolition of the *Zamindari* system, land tenure is now more rational. The average holding in India is tiny and often split into scattered pieces. Five major categories of land holding are: marginal (below 1 ha), small (1–2 ha), semi-medium (2–4 ha), medium (4–10 ha), large (10 ha and above). During 1980–81, the total numbers (millions) of these holdings in India were: marginal (50.12), small (16.1), semi-medium (12.5), medium (8.1) and large (2.2). Fragmentation of land holdings is continuing unabated.

Livestock rearing is an integral part of the various farming systems. Arable agriculture contributes a major fodder resource in the form of crop residues which are extensively fed to the animals. Wheat straw is transported from surplus areas such as Punjab and haryana to deficit areas, mostly the Himalayan hills. Fodder crops like oats, Egyptian clover, fodder rape and chicory are grown during winter, while maize, pennisetum, sorghum and cowpeas are sown during the summer. Cultivation of forage crops is restricted to irrigated areas and land rich farmers. Sale of green fodder through retail outlets is a common practice. Cultivation of perennial grasses such as napier and napier X Bajra (*Pennisetum*) hybrids is becoming popular. Intensive fodder cultivation is restricted to States such as Punjab, haryana, Uttar Pradesh, Madhya Pradesh, Gujrat, Maharashtra, Andhra Pradesh and Karnatka. The area cultivated for fodder amounts to 4% of the total cultivable area. However, exclusive pastures and grasslands are widespread and are grazed by domestic animals. The total area of permanent pastures and grasslands is about 12.4 M ha or 3.9% of the country's geographical area. An area of 15.6 M ha, classified as waste land, is also used for grazing. Forests, and their associated grasslands and fodder trees, are another major source of grazing and fodder collection.

The ruminant sector provides a significant proportion of self-employment opportunities and supplements the income of most sections of India's agrarian society. Livestock are more significant for people living in drought-prone, hilly, tribal and other less favoured areas where crop production may not be certain. Animal raising is a means of supporting the earning capacity of landless, marginal and small farmers. The importance of this sector can be accessed from the fact that the gross value of output from the livestock sector was about Rs 797 billion (USD 1 is equal to about Rs. 40) in 1994–95 or about 20% of the total output from the agricultural sector. The contribution in the late 90s of the livestock sector to GDP was 8.5 to 9% (Anon. 1997 b).

India is also a major exporter of various livestock products and during 1996–97 livestock products worth Rs 8 130 M were exported (APEDA 1997). The country possesses 26 indigenous breeds of cattle and 6 breeds of buffalo. The total size of the livestock population in 2001 was 191.2 M cattle, 94.4 M buffalo, 60.4 M sheep and 120.9 M goats (Table 1). By 2005 cattle numbers had decreased slightly to 185.0 M, buffalo numbered 98.0 M, sheep 62.5 M and goats 120.0 M. India produced 1.5 M tonnes of beef and veal, 1.4 M tonnes of buffalo meat, 0.23 M tonnes of sheep meat, 0.47 M tonnes of goat meat and 84.8 M tonnes of milk in 2001 (Table 1); by 2005 production levels were beef and veal 1.5 M tonnes, buffalo meat 1.5 M tonnes, sheep meat 0.24 M tonnes, goat meat 0.48 M tonnes and milk 91.9 M tonnes. As well as imports of live cattle from neighbouring countries India has substantial

Table 1. India statistics for ruminant numbers, beef, veal, buffalo and sheep meat and milk production, cattle and goat and milk imports for the period 1995–2005

Item	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cattle nos. (million)	201.7	200.8	198.9	197.0	195.1	193.1	191.2	189.3	187.4	185.5	185.0
Buffalo nos. (million)	88.4	90.1	89.9	91.0	92.2	93.3	94.4	95.5	96.6	97.7	98.0
Sheep nos. (million)	54.1	55.3	57.5	58.2	58.9	59.6	60.4	61.1	61.8	62.5	62.5
Goat nos. (million)	118.4	119.5	122.7	122.3	121.8	121.4	120.9	120.5	120.1	120.0	120.0
Beef and veal prod. (million mt)	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5
Buffalo meat prod. (million mt)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Sheep meat prod. (thousand mt)	213.3	217.8	222.5	225.6	228.0	229.2	230.4	232.8	235.8	238.8	238.8
Goat meat prod. (thousand mt)	450	454	458	462	466	467	469	470	473	475	475
Total Milk prod.* (million mt)	65.3	66.8	70.7	74.1	78.1	80.8	84.8	86.8	89.3	91.0	91.9
Cattle imports (thousand) mead	37.2	24.1	23.7	3.7	1.4	2.0	2.6	4.7	5.4	5.4	n.r.
Goat imports (thousand) head	30.6	32.2	27.4	21.8	20.3	21.5	27.8	28.2	25.6	15.5	n.r.
Milk equivalent imports (thousand mt)	71.0	6.6	41.0	49.9	216.3	61.0	37.1	76.3	124.6	48.9	n.r.

*Milk from cows, buffaloes and goats

n.r. = no record

Source: FAO Database 2006

imports of dairy products, in particular dry milk. In 2003 and 2004 milk equivalent imports were 124 600 and 48 900 tonnes respectively (see Table 1).

2. SOILS AND TOPOGRAPHY

Major crust movements have been responsible for the sharply demarcated three-fold structural and physiographical divisions of India, each with its own characteristic features: the Peninsula, consists mainly of Pre-Cambrian rocks in a stable shield area; the extra Peninsula consists of folded and faulted sedimentary beds; and an intermediate tectonic rift valley, known as the Indo-Gangetic trough, is filled with a thick deposit of alluvium (Pichamuthu, 1967). These major topographical features have given rise to a mosaic of features, which are unique to the various geographical areas.

Soils are diverse and differ from area to area. Sixteen major types of soils have been recognized. These are red loamy soils (eastern Himalaya, eastern Ghats, Tamil Nadu uplands), red and lateritic soils (eastern plateau, northeastern hills, western Ghats), red and yellow soils (eastern plateau adjoining central highlands), shallow and medium black soils (Deccan plateau, central Maharashtra and Karnatka plateau), medium and deep black soils (central highlands, Narmada Valley, Malwa plateau, Bundelkhand and Kathiawar peninsula), mixed red and black soils (parts of Deccan plateau, Telangana, Bellary and Anantpur regions of Karnatka plateau), coastal alluvium-derived soils (eastern and western coastal plains), alluvium - derived soils (western, northern and eastern plains), desert soils (southwestern Punjab, haryana plains, Rajasthan, Marusthali and Kachchh peninsula), Tarai soils (foothills of central and western Himalaya), brown and red hill soils (eastern Himalaya), saline and alkali soils (Kathiawar peninsula, alluvial plains of Uttar Pradesh, haryana, Punjab and Rajasthan), shallow and skeletal soils (Ladakh and Kashmir). Grey brown soils (foothills of Aravallis), brown forest and podzolic soil (northwestern Himalaya), sandy and littoral soils (Lakashdweep and coastal areas of Andaman and Nicobar islands).

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

The climate may be broadly described as tropical monsoon type. The four seasons are: winter (January–February), a hot summer period (March–May), a rainy southwestern monsoon period (June–September) and a northeastern monsoon period (October–December). In addition, a number of micro-climatic patterns occur. The Kashmir valley and some other higher altitude regions experience a typical temperate climate,

while still higher areas, such as Ladakh, Lahul and Spiti, have a typical cold-arid desert climate. India's climate is formed by the northeast monsoon (winter monsoon) winds that blow from land to sea and the southwest monsoon (summer monsoon) winds which blow from sea to land after crossing the Indian Ocean, the Arabian sea and the Bay of Bengal. Most rainfall in India is caused by the southwest monsoon.

India has twenty agroecological regions (AER). This zonation is based upon physiography, soil characteristics and taxonomy, climate, growing period, land utilization and forest types.

AER-1: Western Himalayas; cold-arid climate; limited cultivation of millets, barley and wheat.

AER-2: Western plains and Kachchh Peninsula; climate is hot and arid; millets and pulses are the main crops.

AER-3: The Deccan plateau; hot arid climate; millets, cotton and oil seeds are the main crops.

AER-4: Northern plains, central highlands, parts of Gujarat plains; hot and semi-arid climate; millets, wheat, pulses, maize, sugar cane and cotton are the main crops.

AER-5: Central highlands, Gujarat plains and Kathiawar Peninsula; hot and semi-arid climate; millets, wheat and pulses are the main crops.

AER-6: Deccan plateau, hot and semi-arid climate; millets, cotton, pulses and sugar cane are the main crops.

AER-7: Deccan plateau and Eastern Ghats; hot and semi-arid climate; millets, oilseeds, rice, cotton and sugar cane are the main crops.

AER-8: Eastern Ghats and Deccan plateau; hot and semi-arid climate; oilseeds, rice, cotton and sugar cane are the main crops.

AER-9: Northern plains; hot subhumid climate; pulses and sugar cane are the main crops.

AER-10: Central highlands; hot subhumid climate; sorghum and pulses are the main crops.

AER-11: Eastern plateau and eastern Ghats; hot subhumid climate; rice, pulses and millets are the main crops.

AER-12:

AER-13: Eastern plains; hot subhumid climate; rice wheat and sugar cane are the main crops.

AER-14: Western Himalaya; warm subhumid to humid climate; wheat, millets, maize and rice are the main crops.

AER-15: Bengal basin and Assam plains; hot subhumid climate; rice, jute, plantation crops are the main crops.

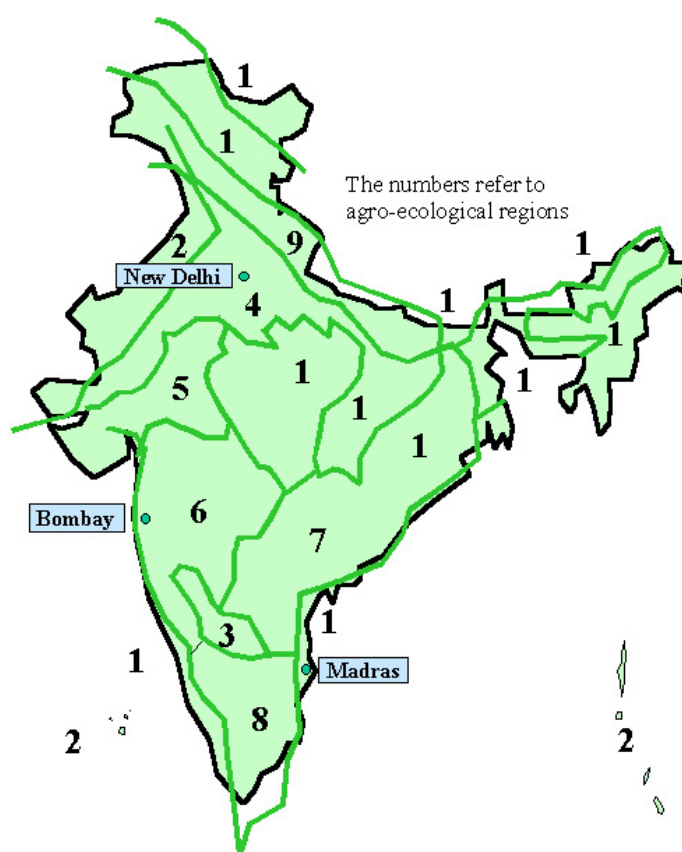


Figure 1. Agro-ecological zones of India

AER-16: Eastern Himalaya; warm per-humid climate; rice and millets are the main crops.

AER-17: Northeastern hills; warm-hot to per-humid climate; forest and rice in patches are the main crops.

AER-18: Eastern coastal plain; hot semi-arid to subhumid climate; rice, pulses and millets are the main crops.

AER-19: Western Ghats and Coastal plains; hot humid to subhumid climate; rice, tapioca, coconut and millets are the main crops.

AER-20: Islands of Andaman & Nicobar and Lakshadweep; hot subhumid climate; forest, coconut and rice are the main crops.

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

Ruminant livestock husbandry has been a major component of Indian agricultural production systems since time immemorial. The major ruminant production systems are: Peri-urban, Urban, Rural and Transhumant. Cattle, buffalo, sheep and goat are the preferred animals. **In peri-urban systems**, milk animals are reared in the peripheral areas of large cities and the milk is carried to the cities for sale. **Urban systems** comprise dairy units of 10–50 cows and buffaloes. It is common to find these systems in and around Delhi, Mumbai, Calcutta, Bangalore and other large cities. **Rural and transhumant systems** are practised in and around villages where community grasslands and forests are the major source of feeding. In urban systems, milk is transported to the cities for sale. Co-operatives have become very common and effective methods for collection and sale of milk. Amul, the largest co-operative society, is the role model for the co-operative movement. The number of registered co-operative societies went from 1 588 in 1970/71 to 69 000 in 1994/95.

The average annual growth rate for employment in the livestock sector from 1972–73 to 1987–88 was 4.15% as against 1.1% for the agriculture sector as a whole. A livestock holding survey carried out a few years ago revealed that the ratio of milking bovines per 100 households rose from 37 in 1981–82 to 46 in 1991–92. The average size of holdings is directly influenced by the fodder resources available. However, in general the entire enterprise is based upon small-holdings (4–6 animals per family). Nevertheless, there are still very large herds in some arid areas where animals are more of an insurance against recurring droughts than an income generating enterprise.

There are different feeding systems for the various livestock rearing practices. In peri-urban and urban systems, the livestock are mostly tethered. Green fodder (Egyptian clover, rape, maize, pennisetums, sorghums, oats) is purchased from nearby rural areas and fed to the animals. This practice is heavily supplemented with crop residues mainly maize, pennisetum, rice and wheat straw. There is significant use of concentrates for milk animals. Premixed cattle feeds are readily available from local markets. Dry animals are adjusted to rural areas.

The transhumant system is prevalent in the Himalayas where there are several nomadic tribes such as the Gujjars, Bakarwals, Gaddis and Changpas, who rear sheep and goat under this system. The animals are moved to subalpine and alpine pastures during summer, while during winter, they are grazed on adjoining plains. The scale of this enterprise is widespread and is practised by a variety of farmers including landless and marginal farmers who have adopted this profession for earning a livelihood. Sale of wool and live animals for meat is their only source of income.

The rural system involves free grazing of community grazing lands and forests, supplemented with green fodder cultivated in the farmer's fields. During lean periods, such as summer and autumn, tree leaf fodder is also used. The preferred fodder trees are *Acacia Artocarpus*, *Albizia*, *Bauhinia*, *Dalbergia*,

Dendrocalamus, *Ficus*, *Grewia*, *Terminalia*, and *Toona*. Concentrates are fed only to lactating animals. While the urban and peri urban systems comprise mostly milk animals, the rural herds are mixed, with goats, sheep, cattle and buffalo. Goats and sheep are, however, reared only on grazing lands. Average quantities of daily feed offered to milk animals are 6.3 kg dry fodder, 5.3 kg green fodder and 0.25 kg concentrates for cows, while a milking buffalo is offered 8.3 kg dry fodder, 2.25 kg green fodder and 0.1 kg of concentrates.

The transhumant system is practised in order to locate the best herbage resources from pastures and grasslands. There are also well recognized pastoral tribes who practise a complete transhumance, moving from one place to another on traditional migratory routes. The dates of migration have traditionally been fixed. Even grazing rights rest with the migratory graziers by traditional usage, though they do not hold proprietary rights over the land. The transhumant system is prevalent in the Himalayan region. However, this system still exists in some states situated in the plains such as Rajasthan, Madhya Pradesh, Tamil Nadu, Gujrat and Uttar Pradesh.

Livestock rearing is strongly integrated with various farming systems. Besides providing drought power and transportation, it is a major source of income supplementation. Since crop residues form the major portion of animal feed, the integration of livestock rearing in farming systems is common. Recently, hortipasture and silvipasture systems of fodder production have been adopted, thus integrating livestock husbandry with plantation crops as well. Under the on-going national programme on watershed development, these systems are being introduced to enhance biomass productivity of degraded lands which in turn helps in increasing the livestock production. Silvi pasture systems with trees such as *Acacia*, *Leucaena*, *Albizia*, *Melia*, and understorey grasses *Cenchrus*, *Chrysopogon*, *Panicum*, *Pennisetum*, *Dichanthium* and legumes *Stylosanthes hamata* and *Macroptilium* are becoming very popular with the farmers.

Although livestock rearing has made remarkable progress in terms of increased production and income of farmers, this sector still requires strengthening of its infrastructure. In 1992/93, the country had 124 intensive cattle development projects, 75 frozen semen stations, 38 613 artificial insemination centres and 135 liquid nitrogen plants. The educational infrastructure for training and extension requires improvement. Pastures and grazing lands are commonly overgrazed and degraded. Therefore improved management, better use of crop residues, and production of dry fodder are required. The Indian Veterinary Research Institute, the Central Sheep and Wool Research Institute and a number of national research centres are active in research on various aspects of ruminant livestock production.

5. THE PASTURE RESOURCE

The grazing of animals takes place on a variety of grazing lands. True pastures and grasslands are spread over an area of about 12.04 M ha. Other grazing lands are available under tree crops and groves (3.70 M ha), on wastelands (1.50 M ha) and on fallow lands (2.33 M ha). Pastures and grasslands have often resulted from degradation and destruction of forests until savannahs are formed (Misra, 1983). True pastures as climax vegetation are found only in subalpine and alpine pastures in the higher altitudes of the Himalayas. Dabadghao and Shankaranarayan (1973) have grasslands classified into five types.

- **Sehima - Dichanthium grasslands** are spread over the Central Indian plateau, Chota Nagpur plateau and Aravallis, covering an area of 1 740 000 km². The elevation ranges between 300–1 200 m. There are 24 species of perennial grasses, 89 species of annual grasses, and 129 species of dicots including 56 legumes.
- **Dichanthium - Cenchrus - Lasiurus grasslands** are spread over an area of 436 000 km², including northern parts of Gujarat, Rajasthan, Aravalli ranges, southwestern Uttar Pradesh, Delhi and Punjab. The elevation ranges between 150–300 m. There are 11 perennial grass species, 43 annual grass species, and 45 dicots with 19 legumes.
- **Phragmites - Saccharum - Imperata grasslands** cover an area of 2 800 000 km² in the Gangetic plains, the Brahmaputra Valley and the plains of Punjab. The elevation ranges between 300–500 m. There are 10 perennial grasses, 26 annual grasses, and 56 herbaceous species including 16 legumes.

- ***Themeda - Arundinella* grasslands** cover over 230 400 km² and include the States of Manipur, Assam, West Bengal, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir. The elevation ranges between 350–1 200 m and there are 37 major perennial grasses, 32 annual grasses, and 34 dicots with 9 legumes.

Temperate - Alpine grasslands are spread across altitudes higher than 2 100 m and include the temperate and cold arid areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal and the north-eastern states. There are 47 perennial grasses, 5 annual grasses and 68 dicots including 6 leguSmall areas of grazing lands are found in the States of Punjab (5.9%) and haryana (8.9%), while 79.3% and 81.7% of grazing lands are found in Arunachal Pradesh and Nagaland, respectively. Punjab and hararyana States have large areas under intensive fodder production. One ha of fodder cropped area supports 11 to 12 adult cattle units. In the states of Arunachal Pradesh and Nagaland, fodder is not cultivated (Singh and Misri, 1993). Livestock production is more efficient from cultivated fodder than from the degraded grazing lands.

Shankar and Gupta (1992) have classified the Indian grazing lands as fragile eco-systems and have ranked them as class IV and V in their land capability classification. The carrying capacity of these areas is 0.20 to 1.47 adult cattle units (ACU)/ha, but the present stocking rates are much higher. In semi-arid areas, the present stocking rates are 1 to 51 ACU/ha against the carrying capacity of 1 ACU/ha (Shankar and Gupta 1992) while in the arid areas, the stocking rates are 1 to 4 ACU/ha against the carrying capacity of 0.2–0.5 ACU/ha (Raheja, 1966). The deterioration of Indian pastures, grasslands and other grazing lands may be ascribed to the large bovine population, free grazing practices, lack of management, and natural constraints like extremes of temperature, steepness of slopes, variable precipitation, and scarcity of moisture in arid and semi-arid situations. The situation in Himalayan pastures is even more alarming due to the severe pressure of the sedentary, semi-migratory and migratory graziers. Overgrazing has caused the near complete loss of edible species. Weeds such as *Stipa*, *Sambucus*, *Aconitum*, *Cincifuga*, *Adonis*, and *Sibbaldia* have heavily infested these pastures (Misri, 1995). Fodder cultivation has remained static at 4% of the total cultivated area. Availability of fodder seed is another limiting factor. The annual requirement for 6.9 M ha under fodder cultivation, and for improvement of an additional 1 M ha of wastelands, is 10 M tonnes of cultivated fodder seed, 25 000 tonnes of range grass and legume seed and 500 tonnes of fodder tree seed per year. Against this, availability is only 20, 15 and 10%, respectively, of these crops (Singh and hazra, 1995a).

6. OPPORTUNITIES FOR IMPROVEMENT OF PASTURE RESOURCES

Despite various constraints on the productivity of pastures and grasslands, the development of grazing areas and fodder cultivation has tremendous potential in India. Research at the Indian Grassland and Fodder Research Institute, Jhansi (IGFRI) and at various other organizations, such as ICAR Institutes and State Agricultural Universities, has developed appropriate technologies for the improvement of these areas. Studies conducted at IGFRI have revealed that the initial protection from grazing of newly improved grasslands can lead to better establishment and higher biomass (3.31 tonnes/ha against 0.93 tonnes/ha without protection). Live-hedge fencing has been found to be economic and suitable. Extensive grazing studies have revealed that the appropriate stocking rates are 25–30, 20, 17, 12 and 6 ACU/100 ha for the management of excellent, good, fair, poor and very poor classes of rangelands, respectively. Basic moisture conservation techniques like contour furrowing, contour bunding and contour trenching can lead to increases in herbage yield (Ahuja 1977). IGFRI studies, undertaken on natural pastures dominated by *Sehima nervosum*, *Heteropogon contortus* and *Iseilema laxum*, have revealed that their production can be increased from 4.1 to 7.6, from 3.4 to 5.6 and from 4.5 to 6.4 tonnes/ha/year by the application of nitrogen at a rate of 40 kg/ha (Shankar and Gupta, 1992). Kaul and Ganguli (1963) have recommended that pastures must have 14% of the area under edible bushes

to obtain best production results. Silvopasture systems on degraded grazing lands (Pathak and Roy, 1995) have enhanced biomass by up to 7–15 tonnes/ha/year. Misri (1986) has reported an additional herbage availability of 35–48 tonnes/ha under hortipasture systems.

Singh and hazra (1995b) have suggested methods to substantially increase pasture seed production in India. A number of highly productive, disease resistant and area specific cultivars of various forage crops, and range species have been developed. hazra (1995) has listed more than one hundred cultivars of fodder crops developed by various research institutes. When fully adopted, these varieties may increase biomass yield from Indian pastures many-fold.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

- **Indian Grassland and Fodder Research Institute, Jhansi-Gwalior Road, Jhansi 284 003.** This national Institute has the mandate to carry out research on various aspects of fodder production, utilization and management. One hundred and sixty scientists are grouped in six scientific divisions and three regional research stations located at Avikanagar (Rajasthan), Dharwad (Karnatka) and Palampur (Himachal Pradesh). Contact: Dr. P.S. Tomer, Director.
- **Regional Stations for Forage Production and Demonstration.** Seven stations have been established for the production of high quality forage seeds and demonstration of proven forage production technologies in various parts of the country. They are located at Hissar, Kalyani, Gandhinagar, Alamadi, Hyderabad, Suratgarh and Shehama. Contact: Animal Husbandry Commissioner, Govt. of India, Ministry of Agriculture, Krishi Bhavan, New Delhi - 110 001.
- **All India Co-Ordinated Research Project (Forage Crops), IGFRI, Jhansi-284 003.** Responsible for national testing and release of forage crop varieties. Contact: Dr. N.P.Malkenia.
- **Central Arid Zone Research Institute, Jodhpur-342 001.** Responsible for development of range management technologies for arid areas. Contact: Dr. M.S. Yadava.
- **ICAR Research Complex for NEH Region, Umroi Road, Barapani-793 103.** Fodder tree management Contact: Dr. K.A. Singh.
- **National Research Centre for Agroforestry, Jhansi-284 003.** Fodder tree production and management. Contact: Dr. K.R. Solanki, Director.
- **BAIF Development Research Foundation, Pune - 411 016.** An NGO undertaking R&D activities on forage production and tree fodder research. Contact: Dr. G. Hegde.
- **G.B. Plant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora-263 643.** Fodder tree inventory, utilization and management. Contact: Dr. S.S. Samant

8. REFERENCES

- Ahuja, L.D. (1977). Improving rangeland productivity. In: *Desertification and its Control*. ICAR New Delhi, pp. 203–214.
- Anon. (1997a). India 1996 - A Reference Annual. Ministry of Information and Broadcasting. Government of India, New Delhi, 733 pp.
- Anon. (1997b). Dairy India - 1997. Priyadarshni Vihar, Delhi, 903 pp.
- APEDA (1997). Agricultural and Processed Food Products Export Development Authority. New Delhi.
- Dabadhao, P.M. and Shankarnarayan, K.A. (1973). The Grass Cover of India. ICAR, New Delhi.
- Hazra, C.R. (1995). Improved Cultivars of Forage Crops for Different Agro- Environments. In: R.P. Singh (ed.) *Forage Production and Utilization*. IGFRI, Jhansi (India), pp. 326–335.
- Kaul, R.N and Ganguli, B.N. (1963). Fodder potential of *Zizyphus* in the shrub grazing lands of arid zones. *Indian Forester*, 39, 623–630.

- Misra, R.** (1983). Indian Savannas. In: F. Bourliere (ed.) *Tropical Savannas*. Elsevier, Amsterdam, pp. 155–166.
- Misri, B.** (1986). Forage Production in the Kashmir Himalayas. In: P. Singh (ed.) *Forage Production in India*. RMSI, IGFRI, Jhansi (India), pp. 32–38.
- Misri, B.** (1995). Range and Forest Grazing in the Himalaya. In: P. Singh (ed.) Workshop Proceedings. Temperate Asia Pasture and Fodder Sub-Regional Working Group. Kathmandu, pp. 28–33.
- Pathak, P.S and Roy, M.M.** (1995). Agrosilvipastoral farming systems for optimizing forage and energy resources in rainfed areas. In: R.P. Singh (ed.) *Forage Production and Utilization*. IGFRI, Jhansi (India), pp. 154–178.
- Pichamuthu, C.S.** (1967). *Physical Geography of India*. National Book Trust, India, New Delhi. 212 pp.
- Raheja, P.C.** (1966). Rajasthan desert can bloom with forage. *Indian Farming*, 15, 47.
- Shankar, V. and Gupta, J.N.** (1992). Restoration of Degraded Rangelands. In: J. S. Singh (ed.). *Restoration of Degraded Lands-Concepts and Strategies*. Rastogi Publications, Meerut, India, pp. 115–155.
- Singh, P. and Misri, B.** (1993). Rangeland Resources-Utilization and Management in India. Paper presented at International Symposium on Grassland Resources held at Huehot, Inner Mangolia, China, August 16–20.
- Singh, R.P and Hazra, C.R.** (1995a). Forage Seed Production-Status and Strategy. In: R.P. Singh (ed.), *Forage Production and Utilization*. IGFRI, Jhansi (India), pp. 309–323.
- Singh, R.P and Hazra, C.R.** (1995b). Forage Seed Production - Perspectives and Strategies. In: hazra, C.R. and Misri, B. (Eds). *New Vistas in Forage Production*. A.I.C.R.P (Forage Crops) IGFRI, Jhansi (India), pp. 323–334.

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