Dairy Farming and Rangeland Resources in Mountain Agro-ecosystems in Uttaranchal

Thesis

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By
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To
My Beloved Mummy and Papa

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CERTIFICATE

This is to certify that the thesis entitled "**Dairy Farming and Rangeland Resources in Mountain Agro-ecosystems in Uttaranchal**", submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Science with major in **Dairy Husbandry** of the College of Post-Graduate Studies, G.B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona fide* research carried out by **Miss Babita Bohra**, Id. No. 28790, under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

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R. J. Sharma
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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss Babita Bohra**, Id. No. 28790, a candidate for the degree of Doctor of Philosophy in Animal Science with major in **Dairy Husbandry**, agree that the thesis entitled **"Dairy Farming and Rangeland Resources in Mountain Agro-ecosystems in Uttaranchal"**, may be submitted by **Miss Babita Bohra** in partial fulfillment of the requirements for the degree.

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Acronyms and Abbreviations

A	Abundance
ADF	Acid detergent fibre
AIA	Acid insoluble ash
CF	Crude fibre
CFB	Complete feed block
CP	Crude protein
CPR	Common property resources
DAP	Draught animal power
DM	Dry matter
EE	Ether extract
F	Frequency
Ha	Hectare
HKH	Hindu Kush-Himalayas
IVI	Important Value Index
masl	Meters from average sea level
NBDMD	Nylon bag dry matter digestibility
NDF	Neutral detergent fibre
NFE	Nitrogen-free extract
OM	Organic matter
PPR	Private property resource
TA	Total ash
UMMB	Urea-molasses-mineral block
VDC	Village dairy cooperative

Contents

INTRODUCTION

Introduction

Dairy is a rapidly growing sector. Growth of this sector in India has been so rapid that all the other countries have been left behind in terms of annual milk production. India also supersedes other countries in terms of large populations of dairy animals. India is endowed with the largest livestock population in the world. There are some 219 million cattle, 94 million buffaloes and 123.50 million goats in India accounting for about 16, 57 and 17 percent of the world's total dairy animal population, respectively (FAO 2001). India's milk output during 2003-2004 was estimated to be 91.1 million tones. Thus India continues to be the largest producer of milk in the world. Per capita availability also increased 238 g/day in 2003-2004 from 202 g/ day in the 1996-97. The growth rate of milk production is about four percent against the population growth. Brighter side of India's emerging as a leading milk producer is this that it has been sustaining this position now for about a decade and is likely to continue to occupy this status in the years to come.

Vast potential of livestock sector is easily conceivable. In the year 2004 about 19 million people worked in livestock sector. The contribution of livestock and fisheries sector in the total GDP during 2000-2001 was 7.35%. According to the sample survey the estimate of employment in animal husbandry sector was 11 million in the principal states and eight million in other states which is 5% of the total working population. The contribution of milk alone (Rs.

103,804 crores) was higher than the paddy (Rs. 73,964 crores) and wheat (Rs. 43,815 crores). The total earning from the livestock, poultry and related products was Rs. 4224 crores in 2002-2003. Out of the total exports, leather sector accounted for Rs. 2470 crores in value terms. Marketing of milk and milk and milk products in India, however faces a problem. India lags far behind in the export of milk and other dairy products which is due to the conditions and polices imposed on the third world countries by the WTO. The European Union, New Zealand, Australia, and USA dominate in world's milk market with about 85% export to the global market, especially to the third world countries. The New Zealand and Australia export 80% and 30% of their milk produced, respectively. India has not fulfilled "world market standards" for exporting milk (Hemalatha and Reddy 2001).

Strides upon strides in milk production in India are against all odds. The conventional norms of dairy farming have been betrayed by farming populace on many grounds: Firstly, there are some 28 descript indigenous breeds of cattle in India which are mostly draught type and dual purpose; owing to their poor production potential, they are seldom pursued to be reared for milk production. Farmers have not replaced them with exotic or crossbreds to an appreciable extent. There are seven well described buffaloes in India. Regarded as "black gold", the buffaloes are treated as the dominant milch animal in India. Secondly, cultivated fodders, especially the leguminous ones, are advocated for increasing milk production. Farmers, however, largely depend on crop residues and village common lands for animal feeding. Not more than 3-4 percent of the arable land in India is devoted to fodder cultivation (Singh *et al.* 1995; Singh and Bohra 2005). Feeding practices adopted by majority of farmers result in low cost of milk production. Thirdly, modern animal husbandry practices advocate use of modern medicine. Farmers in rural areas, nevertheless, still depend to a large extent on ethno-vet medicines which, they have shown, are of vital value in health management (Joshi *et al.* 2005). Fourthly, India's dominance in milk production is not because of large dairy units. It is the domain of landless labourers and small and marginal farmers, having 1-2 milch animals, possessing about 70 percent of the total milch animals in the country. This contribution of the poor and marginalized to the dairy sector of India deserves an appreciation.

This state of dairy development acquired largely through local resources, defying conventional tools of development, is a proud indicator of rural India's socio-economic development contributed by the most deprived and marginalized masses of rural areas. It must be cherished, valued and celebrated. There is, however, no point of complacency. This sector needs steady growth. What needs to be more emphasized is the augmentation of natural resource base, particularly the rangeland resources to supply feed on sustained basis and indigenous livestock resources to preserve, conserve and replicate superb genes.

The Uttaranchal State like other mountainous States in India – and in fact, like all the areas in the Hindu Kush Himalayan (HKH) Region – is very rich in its livestock resources. There are some 21.88 lakh cattle, 12.28 lakh buffaloes, 11.58 lakh goats, 2.96 lakhs sheep and 0.17 lakh equines in the State of Uttaranchal, as per the 2003 Livestock Census (Singh and Singh 2005). The cattle, buffaloes, goats, sheep and equines constitute about 45, 25, 24, 3 and 0.4 percent of the total livestock population in the State, respectively. The livestock data, as obvious, reveals highest proportion of the dairy animals in the livestock population. Though cattle are the preponderant and the most popular species, buffaloes are becoming increasingly preferable dairy animals over past few decades.

Dairy farming has strong linkages with various components of the environment it operates in. Land use in an area, or the type of a farming system, has enormous bearing on the performance of dairy farming. In mountain areas, farming systems have substantial area under non-cultivated use. Large chunk of this ecologically crucial area encompasses rangelands. Rangelands are ecological core areas, not merely the support areas as they are often referred to by some scientists. Their role in and contributions to a farming system, and consequently to a farming community, is of enormous value. Dairy farming in mountain areas should be seen and analysed against the backdrop of what is the largest component of a farming system, i.e., the rangelands.

Rangelands and dairy farming are complementary to each other in an integrated farming system such as in the mountains. In this farming system generally uncultivated fodders are used as a source of livestock feed. 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 the major source of grazing and fodder collection in the hilly areas.

Rangelands are not only crucial for livestock production, but also critical for crop production. Agriculture is the main occupation of the people and about 70% of the population in the mountains is engaged in this activity. Livestock rearing is complementary and integral to mountain farming systems. More than 60% of the Hindu Kush-Himalayan (HKH) region consists of rangeland ecosystems. These rangelands support the livestock industry, accommodate important watershed functions, and provide valuable and biologically diverse resources. Rangelands, according to the Society of Rangeland Managements Website, are the lands on which the native vegetation – predominantly grasses and grass like plants, forage or shrubs – is suitable for use by grazing and browsing. These lands encompass approximately half of the earth land surface (Sidahmed and Rota 2004). Some estimates yet place 70% of the world's total areas as rangelands (Zhaoli 2004). They constitute the key component of the mountain farming systems. These ecosystems not only render crucial ecological services even to far off forelands, but also contribute to the livelihood security of livestock dependent–communities/ pastoralists dominating the region. The low and high altitude rangelands of the Indian Central Himalayas are spread over an area of 2.9 $X10^5$ ha. Rangeland supports a variety of herbs, shrubs and trees many of which are of great economic importance. At mid-altitudes in the mountains, rangelands are a result of either burning of or continuous extraction of fuel, fodder and timber from the forest ecosystems at the rates exceeding the carrying capacity of these ecosystems. Rangeland at high altitude in the Greater Himalayas is the natural ones composed of the climatic climax vegetation. These alpine pastures are locally known as Bugyals. The area under the natural rangelands is covered with thick snow for about six month in a year. These natural pastures constitute about four percent of the geographical area in Indian Central Himalayas. They are utilized by migratory animals of the transhumant communities as well as by animals of inhabitants of the adjacent areas, which are invariably the livestock–dominated farming systems.

The mountain rangelands provide habitats for a variety of feed resources many of which are highly nutritive for the livestock. These ecosystems support a variety of farm animals, e.g., cattle, buffaloes, goats, sheep, horses, mules, ponies, yak, mithun, rabbits etc. Livestock are a backbone of the land-based livelihoods in the mountains. There are numerous families, especially of ancient tribes and nomads owning large herds of the domesticated animals, for which pastoralism is the only source of livelihood. Due to the availability of forests and rangelands under common property resources (CPRs) regime, farmers customarily depend on uncultivated fodders (tree leaves, grasses and herbaceous plants) rather than on the conventional cultivated fodders.

Feed is the most critical input of dairy farming. Huge livestock population in India requires feed and fodder for its sustenance. Adequate supplies of feeds are also must to keep the livestock sector thriving for socioeconomic development. The total animal requirements of green fodder, dry fodder and concentrate at national level are 761, 650 and 79.4 million tones respectively, where as availability of these items is estimated at only 573, 387 and 42 million tones, respectively (Ranjhan 1997). Therefore vast gap exists between the availability and requirement of the feeds in the country. In mountains feed demand and requirement gap is still wider. Seasonal fluctuations in the feed supply system are acute and often detrimental to livestock health and production.

As a result of growing human population and development pressures in the HKH Mountains, land resources per household are decreasing, with subdivision and fragmentation of land over the generations. Although the number of livestock per household is decreasing, the number of livestock overall has not decreased enough to match the reduced per capita resource availability. This is because livestock are an integral part of large majority of subsistence households and must be maintained at a certain minimum threshold (Tulachan and Neupane 1999).

Geologically, the Himalayan mountain region constitutes one of the most fragile ecosystems on earth. Delicate ecology of the mountains makes them one of the most interesting landmasses in the world. Development activities going in the mountain areas have tremendous bearing on the adjacent plain areas. Dairying being one of the major land based activities and relying heavily on the rangelands is bound to affect the inherent ecological setting of the areas. Issues relating to dairy farming and rangeland resources are very much linked to each other. The dairy sector cannot be seen, analysed or addressed by delinking from the rangeland resources, which are the major feed sources for the former. Dairy farming too has implications on rangeland ecology. This study, therefore, is an attempt to contribute to augment the largest part/ component of an agro-ecosystem and one of the core economic activities involving all rural masses.

Objectives

1. Assessment of the current state and performance of dairy production in the selected mountain villages: population, composition, size, production and reproduction performance of dairy animals under existing traditional management.
2. Analysis of the dairy farming-rangeland linkages and the contributions of rangelands to dairy farming and other life-supporting activities.
3. Quantification of the impact of the supplemented feed on the performance of dairy animals.
4. Evaluation of diversity, density and frequency of herbage species in the rangeland ecosystems.
5. Nutritive evaluation of all the feeds extracted from the rangelands and used by the farmers.
6. Documentation of traditional management of rangeland resources and analysis of the traditional system through modern perspectives.

REVIEW OF LITERATURE

Review of Literature

Mountain farming systems comprise large area under forests and rangelands. A number of forest types occur in the Himalayas, which are distributed widely with the gradient of elevation ranging from sub-tropical to temperate and alpine zones (Champion and Seth 1968; Singh and Singh 1992). Livestock are the main component of the mixed farming systems in the Himalayan areas. They covert the energy of forests, grasslands and crop residues into useful products, like draught power, milk, meat, wool, manure, etc. and thus play a crucial role in livelihood systems. Animals are part of an integrated system with crops or trees and their role and function is often much wider than simply as providers of milk and meat, as in developed countries (Ørskov 2005). Moreover, in mountain areas, sustaining agriculture without livestock is virtually unimaginable (Singh 1998a). A number of comprehensive studies have been conducted on livestock production systems in the mountain areas (Jackson 1985; Jodha and Shrestha 1990; Singh 1999, 2000, 2001). The livestock provide tangible and intangible benefits to the mountain farmers (Singh 1998a). Smallholder dairy farming is increasingly gaining importance as a source of family income in mountain areas for quite some time (Singh 2000, 2001; Singh *et al.* 2001d).

Hills and mountains of the Himalayas are endowed with a rich natural resource base, which is conducive to dairy development. There is a dynamic relationship between common property resources, livestock and crops (Singh

2002a). Mountain areas of the Uttaranchal State, like other hill areas, have, therefore, rightly been earmarked for dairy development.

2.1 Livestock production systems

Two types of specialized livestock production systems are emerging today. The first is in the valley areas with good access to markets. Here, a specialised cattle milk production system based on Jersey crossbred is emerging. Some areas in Himanchal Pradesh practice such specialization (Singh 1997, 1999). Most crucial areas for reliance on cash income through milk are those near urban areas, as they are benefited with ready market near by. In Uttaranchal, the picture is somewhat different from that of Himanchal Pradesh. Here, more buffaloes are dominating the herd than the crossbred cattle (Singh and Tulachan 2002).

According to Misri (1995), the major ruminant production systems are peri-urban, urban, rural and transhumant. Rural and transhumant systems had been followed by the mountain farmers. Pariyar (1996) reported that in Nepal there are three types of ruminant production systems: transhumance, sedentary, and stall fed. The sedentary systems prevail at the lower altitudes of the mid altitude of the mid hills (900 -1000m) and utilize all the available forage in and around the village. Transhumance system is practiced in the temperate, sub-alpine and alpine regions where the cattle, buffaloes, sheep and goats migrate from one place to the throughout the year. Two kinds of herd are involved in full tranhumance: yak-chauri and sheep-goat (Palmieri 1976, Alirol 1979, Brower 1987).

With the addition of exotic/ crossbred/ improved animal and reduction of uneconomic animal in livestock population in the country, the composition of Indian livestock has remarkably changed during the last 20 years (Tiwari and Divedi 1997). Small and marginal farmers contributing 62% to the total milk produced yearly owned 70% of livestock population (Varma 1997).

According to a study by Singh (1998a) the number of cattle per household was the largest in the middle Himalayan zone under traditional agricultural system and the smallest in the villages under transformed agriculture in the same zone. The cattle size and sex ratios are major determinants of draught animal power management in mountain farming systems.

An analysis of temporal changes in ruminant population in Uttaranchal hills between 1961 and 1999 shows an overall increase of about 15 percent in the total ruminant population. The most noticeable change over a period of about four decades is an over whelming increase in the population of buffaloes (55%) and goats (50%). A considerable decline in the population of cattle (5%) and sheep (14%) are another note worthy changes. With gradual emphasis on dairy sector, milk production in Uttaranchal hills has increased from mere 419 thousand MT in 1979-80 to about 715 percent over this period. Whereas milk production from cows has increased only 19 percent, buffalo milk production has leapt by 111 percent over this period. The milk production increased in the Uttaranchal hills thus is largely thanks to buffaloes' contribution. Presently, buffalo population contributes more than 60% of the total milk production in the region. Milk productivity per animal has increased over a period of two decades. In case of a cow it has increased from an average of 1.33 kg per day in 1979-80 two 230 kg per day in 1999-2000. An average increase in milk yield from 2.55 kg per day to 3.71 kg per day over the same period has been recorded for a buffalo. Lactation yield increase per cow (73%) has been far higher than per buffalo (45%). The attributable to the institutional polices and programmes focusing on cows and negligence of buffaloes (Singh *et al.* 2001a, 2001b, 2001c).

Rich body of literature on the feeding of different species of livestock in mountain areas is available. There is, in general, no particular set of standards that the hill farmers would follow. They, like their counterparts, follow the thumb rules of nature while managing feeding of their livestock. Inferences given below are based on the studies by GB Pant University (1982), Jackson (1985), Singh (1985, 1998a), Singh and Naik (1987), Singh and Sharma (1990), Singh (2000), Singh et al. (2001a), Singh and Vaidya (2002), and Tulachan *et al.* (2002).

Smallholder dairy farming is becoming increasingly popular in many of the accessible pocket areas of HKH. It has also been the driving force behind the transformation of the rural economy in many parts of the Nepalese and Indian hills. An established market for fresh milk and development of milk cooperatives and milk collection centres has made this possible (Tulachan and Neupane 1999).

Describing the dairy farming characteristics in various milk sheds of the Central Himalayas, Singh (2000) has sketched the maintenance costs of dairy animals reared at various sites/ altitudes of the mountains. Singh (1997, 1999) has done similar studies in Himanchal Pradesh Hills.

GB Pant University (1982), Jackson (1985), Singh (1985, 2000, 2002a), Singh and Sharma (1990), Tulachan and Neupane (1999), Singh and Vaidya (2001), Tripathi (2001), Bohra (2003), Singh *et al.* (2003) have presented Strategies for livestock/ dairy development in Indian Central Himalayas. Since the key constraint to livestock production is the paucity of feed resources, augmentation of feed supplies through natural resource management and land based feed resources has been regarded as potential approach to the development of sustainable dairy farming.

2.2 Dairy farming in the mountains

There are now varying degrees of commercialization within these mixed crop-livestock farming systems. In fact, livestock production systems are becoming quite dynamic in certain pocket areas of the mountains with accessibility to road networks and market for milk. Farmers are being provided with a strong incentive to keep livestock, not just to fulfill the traditional role of providing draught power, meat, milk and manure to the households; but also to generate cash income through the sale of milk. In these areas, there has been a shift in management practices, with linkage with Common property resources (CPRs) to breakdown (Tulachan and Neupane 1999). Tulachan (1998), Tulachan and Neupane (1999), Singh (2001, 2005), Singh *et al.* (2001a, 2001b, 2001c), Bohra and Singh (2005), Bohra *et al.* (2005), Richard *et al.* (2005), Singh and Joshi (2005), and Singh and Bohra (2006) have presented detailed information regarding various aspects of dairy farming, including milk consumption pattern and various factors affecting in the different areas of the Hindu Kush-Himalayan (HKH) region.

In the Himalayan Mountains the majority of the farmers operate in the mixed crop-livestock farming systems. There are great many different types of agro-ecosystems in this region. Geographic and topographic variations (mountain specificities – Jodha *et al.* 1992) have combined to provide a microcosm of the earth's vegetation types and farming systems (Tulachan and Neupane 1999, Singh 2000). Owing to inherently rich resource base, such as widespread areas under rangelands, the mountain areas of Uttaranchal state, like the other similar areas, have therefore, rightly been earmarked for dairy development. In these areas, there has been a shift in management practices, with linkage with CPRs (Tulachan and Neupane 1999).

2.2.1 General management

The housing system of animals is not to any standards. Poorly ventilated and dark houses for animals to be tied in during night are the common scenarios in mountain areas. Generally the ground floor of the living house is used as livestock shed. The upper story is used for housing a family (Singh 2000). This architect might be compatible with area specificities, as what is certain is that animals in this housing system are least likely to suffer from cold waves during winter season.

Prophylactic measures, like vaccination, deworming, etc. are also uncommon and most of the animals in the area are treated using indigenous preparations, made of locally available crop/ forest products. Unhygienic conditions in which most of the animals are kept give rise to heavy calf mortality and other problems, particularly prolapse of uterus, poor growth and low milk yield, etc. (Singh *et al.* 2004).

2.2.2 Breeding practices

All the buffaloes are bred naturally in both Kumaun and Garhwal regions. According to a study of Singh (2004) conducted in parts of the Garhwal and Kumaun regions of Uttaranchal, the overall average for cows revealed that 85.92 percent farmers followed natural service, 5.10 percent artificial insemination and rest 8.98 percent both natural insemination and artificial insemination.

In peri-urban areas percentage of artificial insemination appears to be pretty high. In Lohaghat township of Kumaun, for instance, as many as 70 percent of the total cattle are crossbred (Bohra 2003). This, however, would depend on the facilities created by institutional system. As is well known, despite the high priority provided by the Government to cross breeding programme, success stories of the same are rare. Availability of improved bulls for natural service and artificial insemination facilities are poor. This, along with poor and imbalanced nutrition during most of the period of the year, is responsible for delayed maturity leading to higher age at first calving and unusually long intercalving period. The overall average age at first calving and intercalving period are estimated as 52.35±2.05 months and 23.85±0.81 months in indigenous cows, 45.20±2.20 months and 19.30±0.84 months in crossbred cows and 55.48±2.20 and 19.20±0.48 months, respectively in buffaloes, as revealed through the study of Singh *et al.* (2004).

2.2.3 Mineral mixture supplementation

Mineral mixture supplementation to feeding of animals in mountain areas has been suggested in a number of papers and books (e.g., GB Pant University 1982; Bohra 2003; Singh and Bohra 2006), for this rectifies many of the problems livestock face particularly in the season of fodder scarcity. Singh *et al.* (2004) conducted mineral mixture supplementation experiments on cattle and buffaloes in two development blocks of Uttaranchal hills. The selected animals in their experiments were offered mineral mixture @ 25 g/ day till it came to heat and serviced. On the basis of the claims from farmers for positive response to mineral mixture feeding in cows, the occurrence of heat (oestrus) and conception rate with natural service were estimated at 60.00 percent and 93.06 percent, respectively in Tarikhet block and 61.67 percent and 86.49 percent respectively in Narendra Nagar block. This indicated a better response of cows to mineral mixture feeding for conception rate in both the regions. The overall response to mineral mixture feeding in cows for the occurrence of oestrus and conception rate was estimated as 60.56 and 90.83 percent respectively. The overall response of mineral mixture supplementation to buffaloes for occurrence of heat and conception rate were estimated at 54.81 percent and 84.46 percent, respectively. The response was higher in cows than in buffaloes. Some farmers covered in the experiments claimed improvement in health and milk production and regular supplementation of mineral mixture resulted in decreased calving intervals.

2.2.4 Urea-molasses-mineral block (UMMB) supplementation

Effect of UMMB supplementation on milk yield, dry-matter intake, saving in concentrate, body weight change and its economic evaluation in cows and buffaloes in Tarikhet and Narendra Nagar blocks of Garhwal and Kumaun Regions of Uttaranchal respectively were observed by Singh *et al.* (2004). Experiments under field conditions carried out by these workers revealed that average milk yield ranged from 0.950 l/day (39.92 percent) to 1.005 l/day (40.50 percent) during different years with the overall increase of 0.979 l/day (38.55 percent) in the Tarikhet block of Kumaun Region and 0.94 l/day (37.90 percent) to 0.960 l/day (38.55 percent) during different years, with overall average increase of 0.995 l/day (38.32 percent) in Narendra Nagar block of Garhwal Region. The average increase in milk yield of cows in the project area for the whole period was estimated as 0.997 l/day (39.80 percent). The average increase in the milk yield of buffaloes in the whole project area for the whole period (2001 to 2004) was 1.022 l/day (36.72 percent). The increase in the milk yield of cows and buffaloes due to UMMB supplementation during different years were all significant.

According to the same study, the UMMB supplementation significantly increased the intake in both cows and buffaloes. The overall increase in the dry-matter intake of cows and buffaloes were recorded as 1.331 kg/day (20.13 percent) and 1.85 kg/ day (19.51 percent), respectively and these changes were significant. The overall saving in concentrate feeding during the period of UMMB supplementation to cows and buffaloes was estimated at 0.245 kg/ day/ head (36.37 percent) and 0.401 kg/ day/ head (33.91 percent), respectively and these figures were found to be significantly higher. The overall daily net income owing to UMMB supplementation from a cow and a buffalo was estimated to be Rs. 2.95 and Rs. 4.07, respectively (Singh *et al.* 2004).

2.3 Rangelands

Rangeland management is the science and art of optimizing the return from rangeland through the manipulation of range ecosystems (Stoddart *et al.* 1975). In 1973, national committee on rangeland management defined rangeland as "uncultivated areas (although sometimes disturbed by unthoughtful cultivation) that support natural or seeded herbaceous or shrubby vegetation with or without trees". The American Society for Range

Management (1964) defined range management as the art and science of planning and directing range use to obtain sustained maximum animal production consistent with perpetuation of natural resources. Viewed within the system framework, rangeland management has been defined as management of renewable natural resource composed of one or more range ecosystems for the optimum sustained yield by the combination of goods and services (Vallentine 1971).

Rangelands are major ecosystems within the HKH region and, for a large number of local people; they provide the main or the only livelihood resource. At the same time, these rangelands also provide high value ecosystem functions and services (Zhaoli 2004). Many studies would suggest that dismal performance of livestock in the Central Himalayas is mainly attributable to the scarcity of the fodder. CPRs rangelands are the part of, rather than cropland area, in Central Himalayas fulfill most of the livestock fodder requirements (Singh and Naik 1987, Singh 2001). A comprehensive account of fodder trees of India, including those found in grassland ecosystems in the mountains has been provided by Singh (1982). Singh and Naik (1987), Singh (1989) and Singh *et al.* (1988, 1990) have presented their perspective on the utilization of forest based fodder in the mountains. Pandey (1982) and Amatya (1990) have presented details on fodder trees and lopping cycle in the mountain areas of Nepal. Biodiversity is influenced considerably by altitude and slope orientation. Grasslands at lower and mid-altitudes are often interspersed by trees and shrubs. People's management gives performance to the fodder-yielding species. Amatya (1990), Bhatt and Rawat (1993), Bana *et al.* (1996), Bana and Singh (2004), and Singh and Gaur (2005) have identified and documented an impressively large number of fodder species occurring in the rangeland ecosystems in parts of HKH region. Prevalence of individual species is mainly according to altitude and slope orientation. Feeding management is optimized on the basis of lopping cycle of individual species, phenology gives an idea of the lopping cycle of individual fodder species and essence is useful tool for animal scientists and farmer in the mountain areas. It contributes to increase production and develop livestock based enterprises and consequently to socio-economic development of livestock dependent farming community in the region (Bana and Singh 2004).

Rangelands being the core components of the farming systems in the HKH region hold key to ecological integrity, a vital prerequisite of agricultural sustainability (Singh 1995, 1998). Rangelands constitute the core area in the mountain farming systems. Feed and fodder occurring in those ecosystems are utilized by the livestock. Nutrients contained in the rangelands, thus flow into the crop lands via manure (Singh and Bohra 2005). Mountain areas comprise crop-livestock mixed farming systems. The farmers in these areas practice pastoralism. They comprise large size of herds, especially the goats and the sheep (Singh 1998).

Rangelands, in most of cases, are the part of common property resources (CPRs) and fulfill most of the fodder requirements of livestock, far much more than the crop land area (Singh and Naik 1987, Singh 2001). Of late, Singh (1982) gave a comprehensive account of fodder trees of India, including those found in the grassland ecosystems in the mountains. The Himalayan regions are endowed with biodiversity in all the components of the farming systems: forests, grasses, croplands and domestic animals (Singh 1996, Gaur 2004).

In the State of Uttaranchal out of a total 13 districts, 11 mountainous districts, viz., Nainital, Almora, Bageshwar, Pithoragarh, Champawat, Dehradun, Tehri, Uttarakashi, Pauri, Rudraprayag and Chamoli are covered under the Van Panchayat Act 2003. The total number of revenue villages in these 11 districts is 13,729 and the area of Civil-Soyam forests in these villages is 10,47,867 ha. More than 13 thousand Van Panchayats covering more than 5 lakh ha of land are constituted so far (Singh and Singh 2006). The Van Panchayats basically are the CPRs giving the residents opportunities for better and effective management that would be sound system of fodder production in the mountains.

2.4 Available fodder resources in the mountains

The pasture lands have historically been a major source of livestock rearing in the mountains from generations. They have been utilized in a variety of ways in sedentary and migratory grazing. Forests, grasslands and agroforestry systems contain a large number of plants – trees, herbs and shrubs – that provide fodder of varying nutritive values. More than a four dozens of woody perennials – trees and shrubs – occurring at various altitudes of the Himalayan mountains have been listed by Singh and Naik (1987), Amatya (1990), Bhatt and Rawat (1993), Singh *et al.* (1995) and Solanki *et al.* (1999)

in the hills and mountains of the Central Himalayas (Uttaranchal and Nepal). Contributions of uncultivated land to fodder supplies in the hills are far more than that of cultivated land. More than 60% of the fodder requirements of livestock in mountain areas are met by trees and forest floor vegetation (Singh and Naik 1987). According to an estimate by Sundriyal (1995), grasslands and forest grazing lands meet about 50 – 60% of the total fodder needs in Himalayas. A forest ecosystem and woody perennials of the agro-forestry systems provide fodder throughout the year on sustained basis. The grazing of animals takes place on a variety of grasslands. The true pastures and grasslands are spread over an area of about 12.04 million ha. Other grazing lands are available under tree crops and groves (3.70million ha), on wastelands (1.50 million ha) and fallow lands (2.33 million ha). Pastures and grasslands have often resulted from degradation and destruction of forests, until savnnas are formed (Mishra 1983). The true pastures as climax vegetation are found only in sub-alpine and alpine pastures in higher altitudes of the Himalayas. According to Dabadgo and Shankaranarayan (1973), there are five types of grasslands.

1. *Sehima-dichanthium*: These are spread in Central Indian Plateau, Chota Nagpur and Aravallis covering an area of 1,740,000 km^2 and elevation ranges between 300-1200 m. There are 24 species of perennial grasses, 89 species of annual grasses and 129 dicots including 56 legumes.

2. *Dichanthium-cenchrus-lasiurus*: These are found in the north parts of Gujarat, Rajasthan, Aravalli ranges, South Western Uttar Pradesh, Punjab. They are spread over 436,000 km^2, elevation between 150-300m. There are 11 perennial grass species, 43 annual grass species and 45 dicots including 19 legumes.

3. *Phragmites-saccharum-imperata*: They cover an area of 2,800,000 km^2 in the Gangetic plains and the Brahamputra valley ranges between 350-1200m.

4. *Themeda-arundinella*: These grasslands cover over 230,400 km^2 and include the states of Manipur, Assam, West Bengal, Uttaranchal, Himanchal Pradesh, and Jammu and Kashmir. The elevation ranges between 350-1200m and there are 37major perennial grasses, 32 annual grasses and 34 dicots with nine legumes.

5. Temperate-alpine: These are spread across altitude higher than 2100m and include the temperate and cold arid of Jammu and Kashmir, Himanchal Pradesh, Uttaranchal, West Bengal and North Eastern states.

In the states of Arunanchal Pradesh and Nagaland too, fodder is not cultivated (Singh and Misri 1993). Nepal pasture lands vary from subtropical grasslands at lower elevations to alpine meadows on ridge tops in the mid hills and high mountain valleys of the inner Himalayan range. Pasture lands mostly located in the mountains and only 4 percent is found in low-lying areas (Table 2.1).

Table 2.1: Pasture land by physiographic regions

Physiographic region	Total land area		Pasture land area		
	Ha (,000,000)	%	ha (,000)	% total land	%of grazing land
Tarai	2.1	14.4	49.7	0.3	2.9
Siwaliks	1.9	12.7	20.6	0.1	1.2
Middle mountains	4.4	29.5	292.8	2.0	17.2
High mountains	2.9	19.7	507.1	3.4	29.8
High Himal	3.5	23.7	831.5	5.6	48.9
Total	14.8	100.0	1701.7	11.4	100

Source: Land Resource Mapping Project (1986)

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.

The situation of Himalayan pastures is even more alarming to the severe pressure of the sedentary, semi-migratory and migratory grazers. 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 areas. Availability is another warning 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 tones of cultivated fodder seed, 25,000 tones of range grass and legume seed and 500 tones of fodder tree seed per year. Against this, availability is only 20, 15 and 10%, respectively of these crops (Singh and Hazra, 1995a).

2.5 Diversity of the fodder species

There is very high degree of diversity of fodder species in the mountains. The favored fodder trees are *Acacia, Artocarpus, Albizia, Bauhinia, Dalbergia, Dendrocalamus, Ficus, Grewia, Terminalia, and Toona* (Misri 1999). The favoured fodder zone lies between 2000m altitude and snow line in Azad Jammu, Kashmir, Swat, Kaghan valleys, and northern areas. These areas provide excellent forage for livestock grazing during summer growing seasons (Khan 1979). Temperate pasture lands are associated with oak or mixed broad-leafed species such as *Quercus* or bluepine forests. The common forage species are *Arundinella hookeri, Andropogon tristis, Poa* spp., *Chrysopogon gryllus, dactylic glomerata, Stipa concinna, Festuca* spp., *Cymbopogon* spp., *Bothriohloa* spp., *Desmodium* spp. *and Agrostis micrantha.* Provision of feed and fodder to livestock in mountain areas would largely depend on the type of ecological zones.

2.6 The rangeland grasses

Grasses comprise the dominant herbaceous vegetation in a typical rangeland. Influence of grasses on man and civilisation has been incalculable but their biology is almost neglected in both graduate and postgraduate studies. Our knowledge and understanding of grass biology remains rudimentary.

Table 2.2: Potential forage species for different agro-ecological regions

High-hills	Mid-hills	Terai
Trifolium repens cv. *Redquin*	*Trifolium alexandrium*	*Trifolium alexandrium*
Dactylis glomerata cv. *Porto*	*Avena sativa*	*Avena sativa*
Medicago sativa cv. *Southern special*	*Pennisetium purpureum*	*Vicia faba*
Medicago sativa cv. *Hunter river*	*Setaria anceps*	*Euchlaena mexicana*
Agropyron intermedium cv. *Dhae*	*Desmodium intortum*	*Sorghum bicolor*
Agropyron elogatum cv. *Camison*	*Melinis minutiflora*	*Vicia sativa*
Trifolium repens cv. *Khumal*	*Stylosanthes*	
Trifolium hybridium	*Pueraria Phaseoloides*	
Lolium perenne cv. *Prior*		
Dactylus glomerata cv. *Tammisto*		
Trifolium repens cv. *184*		
Trifolium repens cv. *Menna*		
Trifolium repens cv. *Huia*		
L.perenne cv. *Tyson*		
D. glomerata cv. *Cambria*		
F. arundinaceae cv. *Dovey*		
L. perenne cv. *Augusta*		
L. glomerata cv. *Apanium*		
T. repens cv. *Mewna*		
L. perenne +*T. repens*		
P. Pratense cv. *Florie*		
T. repens cv. *Huia*		
T. repens cv. *Ladino*		
T. pretense cv. *Pawera*		
T. pretense cv. *Broad leaf*		

Source: Priyar *et al.* (1996)

Plant physiology tends to favour the lofty dicotyledons and gloss over the lowly grasses almost as if the monocotyledonous plants once pigeonholed are scarcely worthy of intense study. Underlying the importance of grasses, Dugger (1972) relates that about 3000 years ago Hebrew prophet Isaiah wrote: "All fresh is grass" and for centuries that concept fascinated philosophers, poets, and theologians who in our more agrarian-oriented past understood that the idea was not only metaphorical but literal. Further stressing the importance of the grasses, he recalls that wheat, rice, corn and other cereal grains – primary staples of mankind since long before recorded history – are all grasses. Grasses with their 7500 species not only far surpass all other vegetation of the world in abundance, but they remain the most important economic family of plants to man.

Puri (1960) classified the grassland communities into three broad categories on the basis of moisture, which have been elaborated by Yadav and Singh (1977) as follows:

(i) **Xerophilous grasslands**: Covering the regions of northwest India, these occur in semi-desert conditions. *Eragrostis* is the dominant grass genus and other common grasses associated with it are *Aristida adscensionis*, *Heteropogon contortus*, *Erimopogon foveolatus*, *Chloris virgata*, *Apluda varia*, *Cenchrus ciliaris*, *C. barbatus*, and *Lasiurus hirsutus*. Prosopis cineraria, Capparis sp., and Balanites sp. Are the usual ligneous species occurring in these grasslands.

(ii) **Mesophilous grasslands**: *Saccharum munja*, *S. narenga*, and *Vetiveria zizanioides* are predominant grasses, spreading in the region of typical moist deciduous forests of Uttar Pradesh. These grasslands may give the appearance of a savanna. Alpine meadows of Himalayas and the grassy downs of the Nilgiris are temperate variations of this type.

(iii) **Hygrophilous grasslands**: These give the appearance of wet savanna, dominated by *Erianthus elephantinus* and *Saccharum arundinaceum*. *Erianthus ravennae* and *Phragmites-Arundo* stands occur on drier and wetter sites, respectively.

Illustrating the evolution of grass family and supporting the treatments of angiosperm phylogeny of Hutchinson (1934), Takhtajan (1959), Cronquist (1968), and Thorne (1968), Stebbins (1972) agrees in placing the family at one of the highest points of the evolutionary "tree" of flowering plants. The apparent simplicity of both their vegetative and reproductive structures results from phylogenetic reduction and is a sign of extreme specialization. The similarity between grasses and other large family of grasslike plants, the sedges (Cyperaceae), is only superficial and is no indication of a true relationship. Sedges differ radically from grasses in the structure of their spikelets and flowers as well as in their chromosomes, which have the peculiar condition of multiple centromeres (Tanaka 1949; Ostergren 1949). In all of these features Cyperaceae are more like Juncaceae, or rushes, than grasses. These two families, as further suggested by Stebbins (1972) are probably derived from a common ancestor.

Development of range grasses for higher forage yields under natural competition with other species requires the preservation of greater adaptability than that needed by crops grown in pure culture under the artificial environment of cultivation. Describing polyploidy as a factor in the evolution and distribution of grasses, Johnson (1972) related that the versatility of polyploids, indicated by their striking role in the evolution of *Graminae*, suggests that induced amphiploidy in particular has a place among techniques for the breeding of such grasses.

Origin of our major grasses is an important factor in any consideration of grasses and their improvement through breeding. Most of the grasses used for hay pasture, and turf, and many species adapted for range seedling in arid and semiarid regions were introduced to the United States from other continents. Hanson (1972) has synthesised the work of grass introduction from one part of the world to the other. The pattern of introduction was established soon after the settlement of the Eastern seaboard, "English grass", a collective term for mixtures of bluegrasses (*Poa* spp.), ryegrasses (*Lolium* spp.), bentgrasses (*Agrostis* spp.), fescues (*Festuca* spp.), and white clover (*Trifolium repens* L.) were seeded by early settlers in New England. The "seed" was obtained in the form of chaff collected from immigrant ships. In Rhode Island hay seed chaff was used to plant hay meadows as early as 1647, and by 1650 there was some movement of hay seed among the NewEngland colonies (Colby 1941). Bermudagrass, *Cynodon dactylon*, which was brought to Savannah, Georgia, in 1751 by Governor Harry Ellis, was considered to be one of the most important grasses in the Southern United States by 1807 (Burton 1951). This observation is substantiated in early agricultural reports from U.S. Commissioner of Patents (Anonymous 1850). Guineagrass, *Panicum maximum* Jacq., was introduced as early as 1813 into Mississippi, and Johnsongrass, *Sorghum halepense* (L.) Pers., was sent to South Carolina from Turkey in 1830. The accidental introduction of dallisgrass, *Paspalum dilatatum* Poir., from South America is thought to have occurred before 1850.

Transfer of exotic germplasm to a new environment provides an immediate opportunity for new ecotypes to evolve by natural selection, provided that some portion of the original introduction survives. Differences in photoperiod, temperature extremes, available moisture, soil fertility, drainage, disease organisms, and insects contribute to the origin of adapted ecotypes (Hanson 1972). The advantages of locally grown clover used were recognized as early as 1850 in the United States (Furgus and Hollowell 1960) and many field experiments have served to confirm this point (Hanson 1972).

The general goal of the plant breeder working on turf species is to modify plant genotype through appropriate breeding procedures that will better fit the plant to its intended use (Long 1972). Although the grass plant is an assemblage of shoots, the individual tiller has been considered by many investigators to be the growth unit of grasses. Productivity depends in large measure on the ability of the plant to initiate tillers and on the later development of these shoots. Within the limits set by genotype, growth of the tiller is responsive to the environment (Laude 1972). External factors that affect growth and development therefore warrant consideration. Investigators studying plant response to environmental factors recognize that the effect of any one factor is conditioned by the magnitude or intensity of others (Langer 1963; Laude 1972).

In the alpine zone of the Himalaya 4000 m asl alpine meadows thrive without any stands of woody perennials. Climate of this zone is too cold and severe to allow woody perennials to grow. Alpine meadows remain covered with snow for more than six months in a year. Come summer and the pastures come under biotic pressure of grazing goats, sheep, cattle and buffaloes.

Yadav and Singh (1977) have given the account of the alpine and sub-alpines grasslands communities and species as indicated in Table 2.3.

Table 2.3. Grassland type, communities and species in the Himalayan Alpine and Sub-alpine Zones

Grassland Type	Altitude, m asl	Grassland Communities	Common Grasses
Agrostis type	4000 - 5200	*Agrostis munroana – Trisetum aeneum, Helictotrichon virescens, Agrostis munroana – Poa pagohila – Poa annua*	*Agrostis canina, A. munroana, Calamagrostis epijejos, Fesuca valesiaca, Hierochloe laxa, Poa annua, P. pagophila, P. stewartiana, P. pratensis, polypogon fugax, Stipa concinna, S. sibirica, Trisetum aeneum, T. clarkei, T. flavescens, T. spicatum and Andropogon tristis*

Danthonia type	3200 - 4200	*Danthonia jacquemontii – Agrostis munroana – Agrostis canina, Danthonia jacquemontii* (var. *minor*) – *Trisetum spicatum and Danthonia jacquemontii – Andropogon tristis*	*Danthonia jacquemontii* var. *minor, Danthonia jacquemontii* var. *jacquemontii, D. cachemeriana, Koeleria cristata, Calamagroitis emodensis, C. epigejos, Festuca lucida, Poa annua, P. pratensis, Brachypodium sylvaticum, Stipa sibirica, Trisetum clarkei, T. spicatum, Andropogon Tristis*
Puccinellia type	Confined to the eroded slopes of alpine region of Kashmir	*Puccinellia kashmiriana – Trisetum spicatum, Poa - Puccinellia*	*Puccinellia kashmiriana, trisetum spicatum, Poa alpinia, P. pratensis, P. annua, Heirochloe laxa.*
Phleum alpinum type	Occurs on well-drained slopes and flats of meadows with deep soils and plenty of soil moisture	*Phleum alpinum, Agropyron, Deschampsia caespitosa - Deyeuxia*	*Phleum alpinum, Agropyron semicostatum, A. canaliculatum, Poa pogophilla, P. jaunsarensis, P. alpine, P. annua, Calamagrostis littorea, C. epigejos, Agrostis munroana, Festuca ovina, F. kashmiriana, Deschampsia caespitosa, Deyeuxia scabrescens*

Source: Adapted from Yadava and Singh (1977)

The temperate grasslands are characteristic of the oak-conifer forest region where the soil is deep and moist. Stable grasslands occur due to moisture of forest vegetation. Animals are allowed to graze in these grasslands during winter season also. The following are the major grasslands types in the temperate zone (after Yadava and Singh 1977):

1. *Chysopogon gryllus* type: *Chysopogon gryllus* is associated with *Koeleria cristata* in the upper part of the temperate region, while at lower latitudes it is associated with *Heteropogon contortus, Themeda anathera* and *Bothriochloa pertusa. Eragrostis anathera, Polypogon fugax, Rottboellia exaltata, Agrostis canina. Poa* and *Festuca* sp. Are the common grasses. The *Chysopogon gryllus* community of this grassland type is replaced by *Cymbopogon stracheyi* community on burning. On overgrazing all the communities are replaced by *Bothriochloa pertusa – Cynodon dactylon* community.

2. *Koeleria cristata* type: This grassland type occurs with *Chrysopogon gryllus* type at lower altitudes and with *Danthonia* type at higher altitudes. *Koeleria cristata, Calamagrostis epijegos, Chrysopogon gryllus, Agrostis canina, Festuca valesiaca, Arundinella nepalensis,* and *Andropogon tristis* are the dominant grasses.

3. *Poa pratensis* type: This exists mostly between 2500 m and 2800 m altitudes. The dominant grasses are *Poa pratensis*, *Poa annua*, and *P. stewariana*.

Themeda anathera type: It occurs between 1700 m and 2200 m within the oak-conifer forest area. *Themeda anathera, Arundinella setosa, A.*

nepalensis, Polypogon fugax, Melium effusum, Bothriochloa intermedia, Oryzopsis aequiglumis, Cynodon dactylon, Festuca gigantean, Phalaris arundinacea, Bromus ramosus, and *eragrostis poaeoides* are the dominant grasses of this grassland type.

2.7 Rangelands and dairy framing

Several studies (e.g., GB Pant University 1982; Singh 1985; Singh and Naik 1987; Singh *et al.* 1988; Singh 2001) suggest that the dismal performance of livestock in Uttaranchal Himalaya is mainly attributable to the scarcity of fodder. Rangelands and other fodder resources in the Himalayas have shrunken due to a number of factors over last few years (Singh 1992, Singh 1998). Rangelands in most of the cases are the part of the common property resources (CPRs) and fulfill most of the livestock fodder requirement, far much more than the cropland area (Singh and Naik 1987, Singh 2000, 2001). Roder *et al.* (2001) have presented comprehensive matter on the feeding of livestock and improving fodder resources in Bhutan. The matter, nevertheless, has to have bearing on all other areas of the Himalayan Mountains.

All these studies would suggest that the uncultivated component of the mountain farming systems – i.e., the rangelands and the forests – have key role to play in the sustenance of dairy farming and are the only key to augment dairy production in mountain areas. Efforts have been made to quantify the role of the rangeland ecosystems in animal production systems (GB Pant University 1982; Jackson 1985; Singh 1985, 2000; Singh and Naik

1987; Singh and Sharma 1990, Singh *et al.* 2001d, Tripathi 2001, Bohra 2003). These studies would also suggest impact of the available feed resources to be derived from the rangeland/ grassland ecosystems on various parameters of dairy production.

Joshi *et al.* (2005) have presented comprehensive use of the medicinal plants and ethno-veterinary practices evolved around them in the mountain areas. Most of these plants occur in the rangeland habitats and local farmers are equipped with the knowledge of their usage. Traditional areas of the Himalayan mountains, according to Joshi *et al.* (2005) are especially rich in the diversity of valuable medicinal plants as well as in the ethno-vet knowledge, as opposed to the transformed areas of the Terai in the Himalayan Foothills and plains in the Famous Indo-Gangetic Valley. Ethno-veterinary practices are vital in livestock health management. These are cost-effective, affordable and time-tested and need be intensively documented which would be a prerequisite for the preservation, recognition and augmentation of this highly evolved, cost-effective, affordable and accessible traditional system.

2.8 Improvement of rangelands

In spite of various constraints on the productivity of pastures and grasslands, the development of grazing areas and fodder cultivation has tremendous potential in India. Kaul and Ganguli (1963) have recommended that pastures must have 14% of the area under edible bushes to obtain best production results. Silvi-pasture systems on degraded grazing lands (Pathak and Roy 1995) have enhanced biomass by up to 7-15 tones/ha/year. Misri (1986) has reported an additional herbage availability of 35-48 tones/ ha under horticulture systems.

Singh and Hazra (1995b) have suggested methods of substantial increase in pasture seed production in India. A number of highly productive and disease-resistant and area-specific cultivars of various crop species have been developed.

Recent years have witnessed some more pragmatic and revolutionary ideas relating to the management of uncultivated lands including rangeland ecosystems. Rangelands are no longer used as a notion of mere grazing lands. "Rangeland management concerns with the multiple uses of rangeland resources rather than seen rangeland simply as grazing land", argues Zhaoli (2004), "At the same time, it recognizes that the public, or more specifically the rangeland users, are important when it comes to making decisions about how rangelands are managed". Rangeland science has shifted from livestock management to rangeland ecology. Rangelands, therefore, have assumed a much wider perspective to be used in their management. While Zhaoli (2004) gives concrete suggestion for the co-management of rangeland resources involving peoples of different HKH countries, Oli (2004) brings to the fore the idea of "corridors" in the management of biodiversity. Singh and Gaur (2005) emphasize improvement of rangeland resources for the conservation of rare and endemic biodiversity including wildlife, eco-tourism and for the cohesion amongst peoples of different countries in which the rangelands share the boundaries.

Rangeland ecosystems, in fact, appear to be the most neglected ecosystems the world over despite their maximum coverage on the land area of the earth. Nevertheless, in recent years these neglected areas are increasingly capturing the attention of the planners, policy makers and the communities dependent on them. Rangeland resource management slowly but steadily acquiring adequate attention and intervention. The present study is also an effort towards contributing to rangeland ecology in the parts of Indian Central Himalayas.

Bohra and Singh (2005) have presented a comprehensive planning for the augmentation of rangeland ecosystems for dairy development in mountain areas. Mountain areas are being regarded as the most pristine ones for the development of organic farming. They further suggest that organic farming and dairy farming in mountain areas, indeed, go hand in hand. If the mountain region were to be developed into a hub of organic farming, then dairy farming should be place at the heart of the process.

Singh and Gautam (2005) stress upon the need to conserve rangeland ecosystems for accelerated ecosystem services, ecological integrity and peace in the Himalayan areas. This would be one of the most crucial roles of the Himalayan rangeland ecosystems towards the promotion of global peace and sustainability.

2.9 Future of livestock enabled services

The on-going rapid processes of globalization are all set to extend market system to all spheres of life and transform everything of direct or indirect human use into a marketable commodity. The livestock-based lifestyles will also not be spared (Singh 2006). As Ørskov (2005) judges it, there are two sytems relating to livestock production systems, viz., i) social value-oriented systems as prevailing in the developing countries particularly in South Asia and ii) market-oriented systems as are seen in the industrialized countries.

Table 2.4: Livestock in the market-oriented and social value-oriented systems

Particulars	Market-oriented systems	Social value-oriented systems
Overall goals for livestock	• Profit maximization, • Cash generation, • Productivity	• Risk minimization, • Family support, • Stability and sustainability
Scientists' role	• Design of systems	• Management of ecosystems
Intermediate targets	• Genetic homogeneity, • Increased production potential, • Single purpose animals, • Nutrient mobilisation	• Biological diversity • Improved maintenance potential • Multi-purpose animals • Nutrient storage
Philosophical approach	• Specialised • Fragmented	• Holistic
Scientific approach	• Single discipline	• Multi-and-trans-disciplinary
Statistical emphasis	• Mean • Main effects	• Variance • Interactions
Natural consequences	• Ecological deficit • High risks • Unsustainability	• Ecological balance • Resilience • Sustainability

Source: Adapted from Ørskov (2005)

In the former system risk minimization, family support and stability and sustainability are the major goals of rearing the livestock, whereas maximum productivity and profit are the main motives in the latter. As the social values get eroded (or become a matter of the market system), scientists' role, targets, approach and emphasis would also be changed (Table 2.4).

Ørskov's (2005) critical observation can also be judged from ecosystem services rendered through the two contrasting livestock production systems. As the social cultural values vanish, our relationship with nature also gets adversely affected. Ethical and aesthetic values inherently associated with the social value-oriented systems value ecosystems and resource conservation. They owe sound ecological basis, are frugal, sustainable and futuristic. Hence they ensure ecological balance which is an imperative for the flow of ecosystem services on sustained basis. As we dissociate ourselves from the value-based system to fall prey to market-oriented systems, what we are sure to loose is the benevolence of natural ecosystems that they could bestow on us through their aesthetic environmental services (Singh 2006). Since impact of the globalization processes on rangeland-based social value-oriented system is going to be phenomenal, it would be critical to look into the future prospects of dairy farming in the mountains and make concrete efforts towards mitigating the problems.

MATERIALS AND METHODS

Materials and Methods

3.1 The study area

The Hindu Kush-Himalayan (HKH) Region comprises of lofty mountains characterized by limited accessibility, marginality, highest degree of fragility, and diversity. Extended into the boundaries of eight Asian countries – Afghanistan, Pakistan, India, Tibet/ China, Nepal, Bhutan, Bangladesh and Myanmar, the HKH Region is amongst the most vulnerable ones in the world. The study area falls in the mountains of the Indian Central Himalayas, the Indian state of Uttaranchal, which has enormous diversity of environments critically influencing the production systems, economy, lifestyles and cultural setting of inhabiting populations. The hill agro-ecological zone comprises lower hills, middle mountains and Greater Himalayas. The Indian Central Himalayas are geographically situated between $28\text{-}31^0$ N and $80\text{-}177^0$ E, covering an area of 53,483 km^2.

3.2 Selection of villages

Three villages on the Development Block of Hawalbagh in the district of Almora will be selected purposely. In the selection process, it was ensured that these villages represent the characteristic features of the mainstream mountain agriculture: the mixed crop-livestock farming systems. Average household in such a village is supposed to have dairy animals.

3.3 Selection of households/ dairy farms

From each village 20% families will be selected randomly for the detailed inventory. Each family would be required to have certain numbers of livestock heads, including dairy animals.

3.4 Collection of information

Pre-structured proformas will be used for collecting information suiting to the objectives of the study.

3.5 On-farm feeding experiments

Livestock diets comprising local feed stuffs were supplemented with purchased feed supplements, viz., complete feed block (CFB) and urea molasses mineral block (UMMB) and were fed to dairy animals under field conditions. There were thus four treatments, namely:

T1: Dairy animals fed local diet

T2: Dairy animals fed local diets supplemented with CFB

T3: Dairy animals fed local diet supplemented with UMMB

T4: Dairy animals fed with local diet supplemented with CFB and UMMB

Local diet varied according to season and comprised tree leaves, crop residues, field weeds, green grass, grass hay and a little concentrate. The concentrate was all home-produced, locally called at *chata*.

Twenty four dairy animals in lactating stage – 16 cows and 8 buffaloes – were selected in each treatment. In total, therefore, there were 96 dairy animals – 64 cows and 32 buffaloes – on which experiments under field conditions were conducted. The animals were kept on experimental diets for five months – mid-October 2005 to mid-February 2006 – and the first month was treated as adaptation period. The experiment thus went on for four months. Data on production were recorded every fortnight.

Feeding system as managed by local farmers was not changed at all. There was no manger system to feed the animals as usually is the scenario in rural mountain areas. The selected families, however, were advised to feed the supplemented feedstuffs in a container in order to avoid wastage of the feed. Many of the farmers followed the instructions, but many of them on occasions violated the advice and followed their traditional way of feeding.

Cows were kept on grazing during the daytime. Grazing length was six to eight hours. Grazing took place either in the open spaces (mainly on roadside, riverside), forest areas and in the fallow fields. At night, they were tied at stall and fed local diet supplemented with experimental diet. The buffaloes were only the stall fed animals. They were fed experimental diets during daytime.

3.6 Estimation of bodyweights by measurement

For the estimation of bodyweights, the following formula was used (GB Pant University 1982; Singh 1998):

Bodyweight of the animal (kg) = $L.G^2/ 10317$

where, L = Length from the shoulder bone to pin bone, in cm; and

G = Circumference of girth just after the fore legs, in cm.

3.7 Selection of rangeland ecosystems

Six sites for the study of rangeland resources would were selected at the mid-altitudes of the Himalayas: three in the Almora and another three in the Champawat district in the Kumaun region of the Central Himalayas.

3.8 Count quadrat or list – count quadrat

Quadrat method of sampling was used for the study of the rangelands. The quadrat is a square sample plot or unit for a detailed analysis of vegetation. Quadrats of any size, number and arrangement may be used depending upon the species area curve. When the species name and number of individual of each species found in the sample plot are recorded, the sample is called count or list quadrat. It is usually used in forest survey work (Chandel and Shukla, 2001).

3.9 Analysis of frequency, density, abundance and productivity of the herbage species

The field study was conducted during summer season and rainy season of the year 2005. For the study of density, diversity, frequency and productivity we used 50 cm^2 quadrat.

3.9.1 Frequency

Frequency as introduced by Raunkiaer (1934) indicates the number of sampling units in which a given species occurs, and thus expresses the distribution or dispersion of various species in a community. From there, % frequency was calculated as follows:

$$\text{Frequency \%} = \frac{\text{Number of sampling units in which the species occurred} \times 100}{\text{Total number of units studied}}$$

Procedure: Lay the required number of quadrat of appropriate size in the vegetation to be studied, and note presence and absence of each species by + or – respectively in each of the quadrats (Mishra, 1968).

3.9.2 Density

The term density represents the numerical strength of species in the community. The density and frequency taken together are of prime importance in determining community structure (Oosting, 1958).

Procedure: Lay a number of quadrat of desired size and count the individuals of each species in each quadrat. Record the total number of quadrat studied. From this density was calculated as follows:

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Total number of quadrat studied}}$$

3.9.3 Abundance

Abundance is described as the number of individuals per quadrat of occurrence. The abundance was calculated as follows:

$$\text{Abundance} = \frac{\text{Total number of individuals}}{\text{Total number of quadrat of occurrence}}$$

3.9.4 Important Value Index (IVI)

IVI of a species is the relative contribution of the species to the whole community. IVI is defined as the "sum of relative density, relative frequency and relative dominance" as:

IVI = Ro + Rf + Rdo

3.10 Proximate analysis of feed and fodder samples

All the feed samples used for the feeding of dairy animals were collected from the study areas for the detailed inventory. The feed samples were analysed for their proximate values, Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), Nitrogen Free Extract (NFE), Total Ash (TA) and Acid Insoluble Ash (AIA) by the standard methods of AOAC (1995). Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were determined by Goering and Van Soest (1970).

3.10.1 Determination of dry matter (DM)

Representative samples of feed and fodder were taken in previously weighed silica crucibles/ tin trays and kept in hot air oven at 100^{0}C for 24 hours. Dry matter was calculated as follows:

$$DM\ \% = (B / A) \times 100$$

Where, A = fresh weight of sample (gm)
B = dry weight of sample (gm)

The dried samples were grounded with a laboratory Willey mill using 2 mm and 1 mm sieve, mixed well and stored in a clean and well labeled polythene bags for pending chemical analyses.

3.10.2 Determination of crude protein (CP)

Crude protein in feed and fodder samples were estimated by using semi automatic Kjeltec method. Accurately 1 gm samples were taken in Kjeltec digestion tube and digested with 1 gm digestion mixture ($CuSO_4$:K_2 SO_4, 1:9) and 12 ml concentrated sulphuric acid. The nitrogen content of the sample was transformed into ammonium sulphate by sulphuric acid digestion. A blank was also prepared by taking all the reagents in digestion tube except the sample. The digested sample of feed and fodder was cooled and subjected to distillation in semi automatic Kjeltec distillation assembly. The ammonia released during distillation was collected into 30 ml of 4% boric acid solution containing mixed indicator (0.2% methyl red and 0.1% bromo cresol green in equal amount in 95% ethyl alcohol). The ammonia collected in boric acid solution was titrated against 0.1 N H_2SO_4. Nitrogen percentage was calculated as follows:

$$\text{Nitrogen \%} = \frac{(V1-V2) \times A \times 0.0014}{B} \times 100$$

Where, V1 = Volume (ml) of 0.1N H_2SO_4 used for titration of sample
V2 = Volume (ml) of 0.1N H_2SO_4 used for titration of blank
A = Dilution factor (volume made by aliquot taken for steam distillation)
B = Weight of sample taken for digestion
0.0014 = Molecular weight of nitrogen (gm) equivalent to neutralize 1ml of 0.1 N H_2SO_4

CP % = Nitrogen % x 6.25

3.10.3 Determination of ether extracts (EE)

Fat and fat soluble components of air dried feed and fodder samples were estimated by Soxtec Avanti manual system. Solvent extraction in the extraction unit was performed in two steps. First the sample was immersed in the boiling solvent to dissolve soluble materials. In the second step, the sample was raised above the solvent surface to permit efficient washing with solvent from the condenser.

After the extraction, the condenser valves were closed by lifting the samples to the upper position. After few minutes most of the solvent is collected via the condenser in a collection vessel. At last the residue of the solvent was evaporated when the air pump was started. Ether extract was collected in previously weighed extraction cups and weighed after cooling in desiccators. The ether extract was calculated as follows:

EE % $= (C - A / B) \times 100$

Where, A = initial weight of extraction cups (g)
B = weight of sample (g)
C = weight of extraction cups with ether extract (g)

3.10.4 Determination of crude fibre (CF)

The sample of feed and fodder after de-fatting as mentioned above were transferred from thimbles to spout less beaker of one litre capacity and each beaker, 200 ml of 1.25% H_2SO_4 was added. It was refluxed for 30 minutes on hot plates after the boiling started and subsequently, filtered through muslin cloth. The residue was washed 5-6 times with hot water until it became acid free. The residual materials on the muslin cloth were again transferred to the respective beaker and each beaker, 200 ml of 1.25% sodium hydro-oxide solution (NaOH) was added. It was refluxed for 30 minutes after the boiling started and subsequently filtered through muslin cloth and washed with hot water for 5-6 times until it became free from alkali. Then, total residue was transferred in a clean dry crucible and dried in hot air oven at 100^0C for 24 hours and then it was cooled in a dessicator and weighed. The residue was then ignited in muffle furnace at 600^0C for 2 hours. After 12 hours crucibles containing ash were removed from the furnace and transferred into dessicator, cooled and weighed again. Weight loss due to ignition was recorded as the weight of crude fibre.

CF % =(B / A)x 100

Where, A = weight of sample on DM basis (gm)

B = weight of CF (gm)

3.10.5 Determination of total ash (TA)

Oven dried 5 gm sample was taken in a previously weighed silica crucible. The crucible along with the sample was kept on heater and burnt till no smoke was given off by the mass of the sample. With the help of metal tong the silica crucible was transferred into muffle furnace and transferred into dessicator, cooled and weighed. Total ash was calculated as follows:

Total ash (%) =(A - B / C)x 100

Where, A = weight of silica crucible with ash (gm)
B = weight of empty silica crucible (gm)
C = weight of sample taken for ashing (gm)

3.10.6 Determination of organic matter (OM)

Organic matter was estimated by subtracting percent ash on dry matter basis from 100 and expressed as percent on dry matter basis.

Organic matter (%) = 100 - [(A-B /C)x 100]

Where, A = Weight of silica dish + ash (gm)
B = Weight of empty silica dish (gm)
C = Weight of sample taken (gm)

3.10.7 Determination of acid insoluble ash (AIA)

Dilute HCl (1:4) 25 ml was added in the crucible containing ash, covered with watch glass and digested for 20-30 minutes on the hot plate. After digestion, the contents were rinsed with water and filtered repeatedly with 5% HCl solution through whatman's filter paper no. 42 into a 100 ml volumetric flask. The filter paper along with the residue left on it was transferred in the same crucible, dried and ignited in a muffle furnace at 600^0C for 2 hours. After 12 hours crucible containing acid insoluble ash was removed from the furnace and transferred into the desiccator, cooled and weighed. The acid insoluble ash was calculated as follows:

AIA % = A x 100 / B

Where, A = weight of acid insoluble ash (gm)
B = weight of sample taken on dry matter basis (gm)

3.10.8 Determination of nitrogen free extracts (NFE)

Nitrogen free extract was arrived at by subtracting the sum of total of crude protein, ether extract, crude fibre and total ash percent from dry matter percent. The nitrogen free extract was calculated as follows

NFE % =100 - (CP% + EE% + CF% + Total ash %)

3.10.9 Determination of neutral detergent fibre (NDF)

Dried sample was ground using 1 mm sieve and then 1 gm sample was weighed into the spout less beaker. One hundred ml of neutral detergent solution, 0.5 gm sodium sulphate and 2 ml of decalene was added into it. The contents of the beaker were then refluxed on hot plate for 60 minutes. Contents were filtered by previously weighed gooch crucible on filter manifold and washed first with hot water 3-4 times and then by acetone twice, transfer the material into crucible and its contents were dried and weighed. Empty crucible weight was subtracted from the total weight of residue plus crucible was concluded as NDF.

$$\text{NDF\%} = \frac{(\text{Weight of crucible + Cell wall}) - \text{Empty weight of crucible}}{\text{Weight of sample}} \times 100$$

3.10.10 Determination of acid detergent fibre (ADF)

One gram dried samples of ground to 1 mm size was taken into spoutless beaker, 100 ml of the acid detergent solution and 2 ml of decalene was added. In this case, sodium sulphate is omitted. The rest procedures were same as in NDF determination except that additional washing was done with hexane twice. ADF was calculated as follows:

$$\text{ADF \%} = \frac{(\text{Weight of crucible + fibre}) - \text{Empty weight of crucible}}{\text{Weight of sample}} \times 100$$

3.10.11 Determination of hemicelluloses

The difference between the NDF and ADF content of sample was considered as hemicelluloses.

Hemicelluloses (%) = NDF (%) – ADF (%)

3.11 Determination of dry matter digestibility

Digestibility was determined by using nylon bag technique as per procedure of Mehrez and Ørskov (1977). Dry matter digestibility of feed samples was carried out by using rumen fistulated animals. All the samples were incubated in duplicate bags taken at each incubation. Incubation time is 72 hours.

For this technique, bag of 9x17 cm size made of 100% nylon cloth of 40-50 um pore size were prepared with double stitching and rounded corners. A 5 g oven dried and ground sample of each feedstuff was taken in a nylon bag and tied with a nylon thread. The bags were suspended in the rumen of the fistulated animals with the help of long nylon cord for 72 hours. The nylon bags were tied to small iron ring to prevent the floating of bags in the rumen. After the lapse of stipulation time, bags were removed from the rumen and washed thoroughly with running water. These residue samples were then dried in an oven at 70^0C for more than 48 hours (till constant dry weight was observed). Each bag was opened after drying and the pelleted residue was broken by hand and transferred to labeled and weighed paper bag, and kept further in an oven till constant weight was observed. After that, the residue was quickly weighed. The amount of nutrient before and after the incubation was taken for calculation of percent disappearances. Digestibility was calculated as follows:

Digestibility % = (A – B / A) x 100

Where, A = Weight of sample taken for incubation (gm)
B = Weight of sample after incubation

3.12 Statistical analysis

The data obtained on chemical composition and nylon bag digestibility of 23 samples were subjected to statistical analysis using CRD as described by Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

Results and Discussion

4.1 Demographic features

A glance of the demographic features of the study villages is necessary to analyse the overall socioeconomic status of the society in reference. There were, on an average, 129 families per village. The average population per village was 913. Matella was the biggest village with 275 families. The average family size of the villages was 7.0. In Etola there were 6.3 persons per family and in Bhanargaon 8.6 persons per family. The average population of Matella, Etola, Mahatgaon and Bhanargaon was 1843, 252, 1006, 403 and 913 respectively. There were 967 women per 1000 men. On an average, in Bhanargaon there were 1205 women per 1000 men and in Matella, 787 women per 1000 men. The average sex ratio of the villages studied was close to that of the state of Uttaranchal, according to Census 2001 (Table 4.1).

Table 4.1: Demographic features of the study villages

Name of the village	Matella	Etola	Mahatgaon	Bhanargaon	Overall
Total no of families	275	40	150	50	129
Total no. of male/ village	1031	126	533	195	463
Total no. of female/ village	812	126	473	235	450
Total population	1843	252	1006	430	913
No. of selected families	20	20	20	20	20
Average family size	6.7	6.3	6.7	8.6	7.0
Sex-ratio female/ 1000 male	787	1000	887	1205	967

Traditionally mountain societies are known for their joint family system. The family size, however, is moderate and is indicative of some fragmentation in the joint family system. The average sex ratio (967) is close to gender-balance but very much varying within villages.

4.2 Landholding size

Landholding size is important to get clear picture of the farm resources available with dairy farmers, land-livestock relationships, have an idea of the over all economic situation of households and asses the available potential of dairy production and its future prospects.

An average land holding size per village was 9.29 nali per family. Average land holding size was more in Etola in comparison to other villages. Irrigated land was albeit 1.45 nali per household per village. The most of land is unirrigated. Cropland in mountain areas, as would be expected, is mostly devoid of the facilities of irrigation (Table 4.2).

Table 4.2: Landholding size (Nali)

Agricultural land	Matella	Etola	Mahat gaon	Bhanar gaon	Overall
Irrigated	-	2.52	3.3	-	1.45
Unirrigated	7.5	9.87	5.8	8.2	7.84
Total	7.5	12.39	9.1	8.2	9.29

Note: One nali land equals 200 m^2; 50 nalis equal to one ha.

There is only little over 10 percent cropland under irrigation in the mountain areas. The average figures of the study villages appear to be in close proximity of the general situation. Situation of the unirrigated cropland is addressed by using sturdy and drought-tolerant varieties of local crops and by practicing traditional strategies mountain farmers have evolved over millennia. The constantly decreasing land holding size, although is compelling due to laws of inheritance, reflects a worrisome state. This size is too little to be dependable on cropping for subsistence needs. Farmers therefore have to depend on market for the purchase of food grains for more than 50 percent of their requirements. Livestock production, mainly the dairy production, is dependent of common lands and therefore is more promising than crop production.

CPRs – including uncultivated forests and grazing lands – contribute enormously to the livelihoods of mountain farmers (Singh 2004). Livestock size in mountain areas does not vary according to landholding size as would be the case in the plains where CPRs have almost vanished. Livestock production in the study area, as also in the entire Hindu Kush-Himalayan (HKH) Range of the mountains.

4.3 Livestock population and composition

Livestock population and composition in selected villages is represented in Table 4.3. On an average, there were 148 bullocks, 95 cows, and 81 buffaloes per village. Amongst the ovine species, goats were the only animals with 108 per village. There were no sheep in the study villages and only one horse per village was recorded. Number of poultry birds per village was 75.

The village economy thus depended on bovine population. The picture of livestock composition, in fact, is varying from area to area in the hills of Uttaranchal. The total bovine population in selected villages was 448. There were 81 percent bovine and only 19% ovine species (Fig 1). Amongst the whole livestock population, there were 64% cattle and 17% buffaloes, besides 19% goats (Fig 2). Amongst cattle, the highest percentage was of bullocks, followed by cows, female calves and male calves (Fig 3). Adult she buffaloes were 84% with 16% female calves (Fig 4).

Table 4.3: Livestock Population in the Study Villages

Livestock category	Matella	Etola	Mahtgaon	Bhanargaon	Overall
Bullocks	316	56	158	63	148
Cows	165	20	143	50	95
Male calves	69	12	53	25	40
Female calves	138	4	98	38	70
Buffaloes	220	16	53	35	81
He buffaloes	-	-	-	-	-
Buffalo male calves	-	-	-	-	-
Buffalo female calves	28	4	23	8	16
Total bovines	936	112	525	218	448
Sheep	-	-	-	-	-
Goats	399	-	30	3	108
Others	-	-	-	-	-
Poultry	275	-	-	23	75
Horses	-	2	-	-	1

Higher proportion of cattle in the herd reveals the fact that cattle are of multipurpose role in mountain farming and livelihood systems. Bullocks are especially regarded as backbone of mountain agriculture. Buffaloes too have significant proportion, for they are the main dairy animals. There were no he-buffaloes in the study area. Farmers of these villages depended on other villages for the service of buffaloes to be met by he-buffaloes. Only a few villages would be found rearing he-buffaloes that too exclusively for breeding purpose. Male calves are deprived of their mothers' milk few days after their birth and starved to death. This practice is due to the fact that male buffaloes have no role in mountain farming systems. An owner of a buffalo bull would charge Rs. 80/- per mount of a buffalo. If the buffalo served by the bull is found to be conceived, the owner would charge Rs. 250 more. Service by a cattle bull, of course, is free of cost. This is to pay a respect to the *gaudhan* (cattle) by the Hindu farming community.

4.4 Livestock holding size

An inventory of the livestock holding size, i.e., number of different classes of livestock per household was necessary for an understanding of family resources and existing production potential. On an average, there were 3.51 bovine per household. Out of this, the number of bullocks per family was 1.21, of cows 0.762 and of buffaloes 0.56 per household. There was just 0.35 cattle male calf and 0.5 cattle female calf. Buffalo female calf numbered 0.12 per household, on an average. There was no male buffalo calf in the sample families and villages. There was on an average, 0.42 goats and 0.36 poultry birds per household per village (Table 4.4).

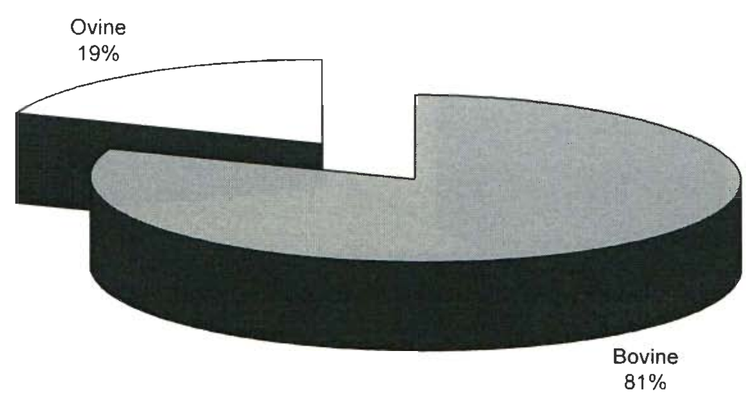


Fig. 1. Bovine and ovine in livestock population

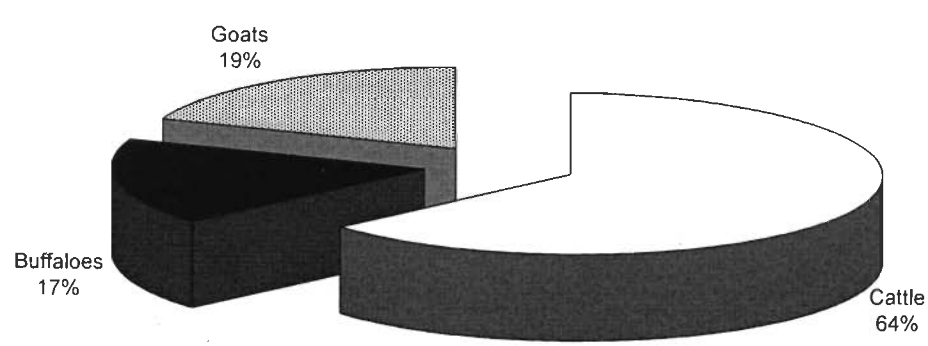


Fig. 2. Livestock composition in the selected villages

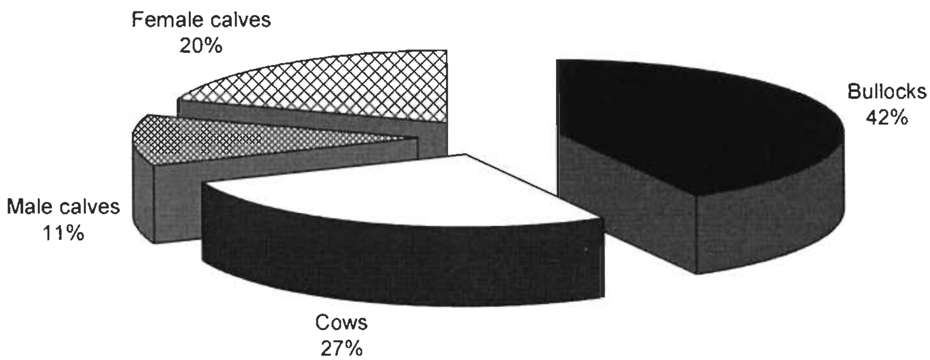


Fig. 3. Composition of cattle in livestock population in the selected villages

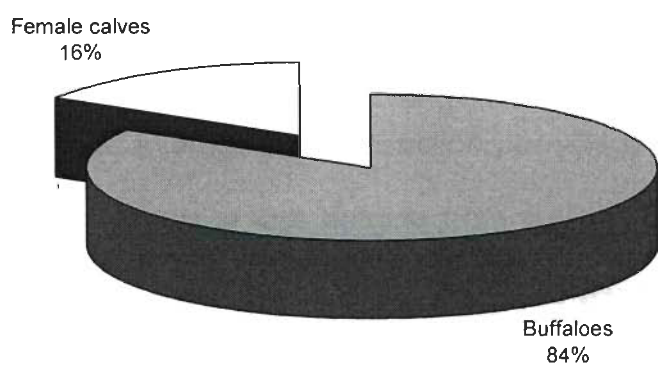


Fig. 4. Buffalo composition in livestock population in the sample villages

Table 4.4: Livestock holding size

Livestock category	Matella	Etola	Mahatgaon	Bhanargaon	Overall
Bullocks	1.15	1.4	1.05	1.25	1.21
Cows	0.6	0.5	0.95	1	0.76
Male calves	0.25	0.3	0.35	0.5	0.35
Female calves	0.5	0.1	0.65	0.75	0.5
Buffaloes	0.8	0.4	0.35	0.7	0.56
He buffaloes	-	-	-	-	-
Buffalo male calves	-	-	-	-	-
Buffalo female calves	0.1	0.1	0.15	0.15	0.12
Total bovines	3.4	2.8	3.5	4.35	3.51
Sheep	-	-	-	-	-
Goats	1.45	-	0.2	0.05	0.42
Others	-	-	-	-	-
Poultry	1	-	-	0.45	0.36
Horses	-	1	-	-	-

4.5 Milk production

Milk production figures at selected households in the study area are presented in Table 4.5. Average milk production per village per farm per day was 1.70 litres. Milk production was ranging from 1.12 to 2.05 litres per day per farm in study areas. Out of the total milk produced per farm per day, 0.37 litres per day was marketed by the farmers. On an average, total 69.66 litre milk was marketed per day per village. Marketing rate was high in Matella and low in Etola. On an average, 23 percent of the milk produced was sold in the market. Generally the morning milk is sold in the market and evening milk is consumed at home. Producer-consumer is the direct channel through which the milk produced is marketed. Deviations in the milk production figures amongst villages were due to different population size of the milch animals.

Table 4.5: Total milk production in study area

Particulars	Matella	Etola	Mahatgaon	Bhanargaon	Overall
Milk production (litres/ farm/ day)	2.05	1.625	2.00	1.125	1.7
Total milk production (litres/ day/ village)	563.75	65	300	56.25	246.25
Milk sold (litres/ farm/ day)	0.72	0.36	0.425	-	0.376
Total milk sold (litres/ day/ village)	198	14.4	63.75	-	69.66

Table 4.6: Mean value of the body weight (kg) of different category of animals

Category of the animal	Mean±S.E.
Cattle	
0-1 year female calf	85.91±17.63
1-2 year female calf	97.84±15.92
2-2.5 year female calf	153.28±8.6
0-1 year male calf	64.01±10.50
1-2 year male calf	79.62±24.77
2-2.5 year male calf	147.41±8.9
Adult cow	232.91±7.9
Bullock	246.04+-4.9
Buffaloes	
Adult buffalo	384.21±18.33

4.6 Body weight of animals

The mean body weights of farm animals are presented in the Table 4.6. A perusal of the Table indicates that the mean of the body weight of a 0-1 year female calf was 85.91± 17.63 kg, of a 1-2 year female calf was 97.84±15.92

kg and of a 2-2.5 year old calf 153.28±8.6 kg. The mean body weight of male calf of 0-1, 1-2 and 2-2.5 year old was 64.01±10.50 kg, 79.62±24.77 kg, and 147.41±8.9 kg, respectively. The weight of an adult cow was 232.91±7.9 kg, of a bullock 246.04 kg and of a buffalo were 348.21±18.33kg.

4.7 Reproductive Performance

Ages at first calving, lactation length, lactation yield, calving interval, service period, etc. are the important traits associated with dairy animals that are vital for the economic sustainability of a dairy farm. Reduction in the age at first calving and dry period leads to an increase in lactation yield and productive life of the dairy animals and economy of a dairy farm.

Information on the reproductive performance presented in Table 4.7 shows that figures for cows are not much satisfactory; for buffaloes, they are reasonably good. Poor performance of cows is a reflection of undernutrition, particularly during lean period. Buffaloes are better fed, for they are especially reared for milk sale. Long dry periods for cows are also a reflection of short lactation period (eight months).

Another important cause of long dry periods in cows is a shortage of bulls. Most of the villages in Uttaranchal mountains do not have a bull. Some time two or even more villages would share a single bull. Many heat periods are undoubtedly lost because the cows cannot be got to a bull, at least in time. Artificial Insemination Centres are few and most of the dairy farms have no access to them. The experiences of the dairy farmers with AI Centres, on the whole, are bad. Our respondents, who have easy access to the AI Centres, would complain of the poor conception rate of the AI.

The situation with respect to breeding buffalo bulls is much better without any institutional programme of any sort. Some two or three villages will share at least one buffalo breeding bull. One reason of it is that services by a buffalo bull fetch handsome returns to the family owning bull.

Table 4.7: Some reproductive performance indicators of dairy animals in the study area

Indicators	Dairy Animal	
	Cow	Buffalo
Age at first calving, years	4 (3.6-4.5)	4.6 (4.0-5.5)
Calving Rate, % per year	56 (53-60)	65 (58-68)
Calving Interval, months	16 (14-17)	15 (12-16)
Number of calving in life time	6 (5-9)	9 (7-12)
Lactation Length, months	8 (6-10)	11 (10-12)
Dry Period, months	8 (6-10)	4 (2-5)
Service Period, months	9	5

Figures in parentheses reflect range

Whereas most of the performance indicators are the same for all locations, dairy animals in VDCs would show some better performance. Average milk yield of dairy animals is the highest in VDCs, followed by the animals in the villages located near market areas. It is due to better feeding and care of dairy animals at the farms having close linkages with the market (Singh 2000).

4.8 Dairy farming-rangeland linkages

Fragility is one of the inherent characteristics of mountain areas. Problems linked to fragility are aggravated as a result of large-scale damage to the environment which, in addition to deforestation, is also contributed by cultivation of crops. Rangelands maintained in the agro-ecosystems are appropriate response to the natural fragility.

In mountain areas, area under cultivation is very small, which is also attributable to the maintenance of rangelands in the agro-ecosystems. Had the farming communities gone for reckless terracing of mountain slopes at the expense of uncultivated forest/ grassland areas, the current area under cultivation would have been pretty large and agrarian picture in the mountain areas would have been altogether different. Problems of the fragile ecosystems then would have been many times more, perhaps uncontrollable. The farming systems involving large areas maintained under rangelands, as of today, have been evolved by the local farmers through trial and error over millennia (Singh 2004, 2005).

4.8.1 Rangelands defined

Rangelands, in essence, are the specific features of the mountain agro-ecosystems. Before further pondering over the linkages between rangeland ecosystems and dairy farming, let us attempt to define the rangelands.

Rangelands, according to the Society for Range Management, are the lands on which the native vegetation – predominantly grasses, grass-like plants, forage or shrubs – is suitable for use by grazing and browsing. Earlier, Stoddart *et al.* (1975) described rangelands as those areas of the world which by reason of physical limitations, low and erratic precipitation, rough topography, poor drainage and extreme temperatures are unsuited to cultivation and which are a source of forage for free ranging native and domestic animals, as well as a source of wood products, water and wildlife. There are several other loose definitions of the rangeland ecosystems. In the Himalayan context, Singh and Gautam (2005) have proposed the following holistic definition: Rangelands are the uncultivated areas or abandoned cultivated areas and occasionally fallow lands that harbour natural or seeded/ planted vegetation of herbaceous and woody species and that serve as habitats of a variety of wild animals, support domesticated animals, provide unique products and ecosystem services especially vital for the livelihoods of livestock-dependent communities.

4.8.2 Nutrient cycles, flows and environment

Nutrients are a collection of chemical compounds, minerals and elements essential to the survival of living organisms (Bourn *et al.* 2005). Plants take up the nutrients from the soil reserves and atmosphere and accumulate in their bodies. Animals take up these from the plant biomass they consume. Not all the nutrients are deposited in the bodies of plants and animals, but certain proportion of these flow through the environment. This passage or flow of nutrients in the environment is a nutrient cycle. In a mountain agro-ecosystem, livestock play vital role in the nutrient cycling.

Nutrient cycles are a sub-set of broader class of global biogeochemical cycles, including water, carbon, oxygen, nitrogen and mineral cycles (Bourn *et al.* 2005). Biogeochemical cycles – especially those of NPK – are significantly influenced by agriculture, the single anthropogenic activity responsible for major ecosystem transformations the world over. Livestock have to play a very crucial role in the recycling of nutrients by voiding dung and urination whilst grazing. Manure collected in the livestock sheds is also transferred into crop fields by humans and thus the nutrients are recycled into soils. The nutrients disposed into cropland soil are not entirely to be obtainable through crop residues. Major chunk of the nutrients comes from uncultivated rangelands which are transferred to cropland soils. Since grazing length in mountain areas is relatively shorter and not all animals (e.g., buffalo species) are reared through daytime grazing, nutrients to be recycled into rangelands are relatively less in amount. But this does not affect the productivity of the relatively ecologically more stable rangeland ecosystem to a significant extent. Deep-rooted trees and a variety of other vegetation in the uncultivated ecosystem take care of the natural fertility maintenance of the system. Greater degree of ecological degradation, however, adversely affects the curtailed flow of nutrients in the rangelands. Greater amount of nutrients to flow into croplands is a precondition for the fertility management of the ecologically more fragile and more vulnerable system.

In mountain agro-ecosystems, such as in Uttaranchal and other parts of the HKH Region, there is no considerable import of nutrients. All the nutrients are produced from within the system itself. Moreover, livestock are not dependent on imported nutrients as would be the case in 'industrial' livestock production units.

In many countries and areas of the world where – under the industrial livestock production system – the animals are kept in high density in piggeries, poultry farms and feedlots, they are dependent entirely on cereal-based diets containing supplementary NPK and various heavy metals, including Cu and Zn. In such a system, relatively small proportions of the supplementary nutrients are absorbed, with most passing through the gut to be excreted with other animal wastes. Net imports of animal nutrients lead to local accumulations and excess soil nutrients, with adverse effect on soil fertility, increased run-off, eutrophication of aquatic systems and contamination of ground water and drinking water supplies (Bourn *et al.* 2005).

In sharp contrast to the intensive high input/ high output systems (including dairying, feedlots, piggeries and poultry farms) as maintained in the industrialized countries are the extensive low input/ low output production systems including pastoralism and intermediate mixed farming systems as operating in the Himalayan mountains. The latter type of the livestock production systems is environmentally sounder and more sustainable. Animal-nature interactions in mountains smallholder systems – indeed – are environment-friendly. Livestock are the most important dynamic factor in managing the ecological or organic faming systems evolved in the mountains over millennia.

4.8.3 Rangelands, ecological integrity and sustainability

An ecosystem is a self-sufficient unit of nature in which there is a definite pattern of nutrient and energy flows vital for the sustenance of the three organisational levels of life, viz., producers, consumers and decomposers. For that matter, agro-ecosystems in the mountains of the Himalayan Region are also self-sufficient and an independent functional unit of nature. Mountain agro-ecosystems incorporate rangelands, livestock and cropland as their integral components. Livestock consume the biomass growing in rangelands a part of which is used to manure croplands. Plant biomass for use as mulch and bedding material extracted from rangeland components also ends up as manure in the croplands. Much of the manuring of the cropland areas is thus done by the nutrients contained in the biomass produced in the rangelands.

Comprising a variety of deep-rooted trees and shrubs along with herbaceous plants and a variety of other wild life forms, a rangeland ecosystem is ecologically more stable than the cultivated land. A thin layer of fertile soil supports shallow-rooted (sometimes deep-rooted) food crop annuals. This soil requires to be constantly fed for fertility maintenance. The cultivated land therefore is ecologically more fragile and vulnerable. Management of this fragility and vulnerability requires constant replenishment of the thin layer of soil in a cropland subsystem. The cropland soils are fed with the nutrients contained in the biomass produced in a rangeland ecosystem. Crop residues produced in the cropland are also fed to the livestock a part of which also ends up as manure.

Livestock constitute the dynamic component of a farming system helping nutrient flows in two ways: transfer of nutrients from ecologically more stable rangelands to the more fragile croplands and recycling of nutrients into the cropland. Livestock thus serve as the living agency to mediate nutrient flows in mountain agro-ecosystems. A part of the energy consumed is retained in their bodies to be used for maintenance and production.

Rangelands impart considerable ecological stability to the whole agro-ecosystem. They are also managed for sustainable production of useful biomass. Rangelands provide variety of fodders for livestock feeding as well as other useful biomass, such as wild fruits, uncultivated vegetables, fiber, medicinal plants, honey, etc.

Maintenance and utilisation of rangelands in the mountains is a unique case of community-based management. Rangelands are spread over community lands (Panchayat forests, civil-soyam forests) to be shared by the residents of *Gramsabha*, a cluster of some three to five villages. Each *Gramsabha* has its own rangeland, which for the local community is jungle. Utilisation of rangeland products is for the entire community of the *Gramsabhas*.

Fodder production and its utilization is the major concern of the Forest Panchayats, the rangeland management bodies in Uttaranchal. Since bulk of the fodder necessary for livestock production is produced in the rangelands, fodder and livestock always remain in the focus of the farming communities in the mountains.

Rangelands through their several attributes and functions, dairying being one of them, contributes to ecological integrity and, consequently, to sustainability of the whole agro-ecosystem. This has been interpreted under the following subhead.

Ecosystem services rendered by an ecologically sound ecosystem are more intense and more useful. These services emanating from well-managed rangelands help maintaining an environment congenial for the productive services of a cropland. Conservation of myriad life forms in its own boundaries, moisture circulation in the whole farming system, and maintenance of appropriate micro-climate are the other intangible attributes of the rangeland ecosystems in the mountain agro-ecosystems. The intangible ecosystem services are often not taken into consideration but are very vital for the efficient functioning and performance of the whole agro-ecosystem on which livelihood systems of rural communities are dependent. A rangeland is a solar-powered ecosystem. The upland terrestrial solar-powered ecosystems are independent (those in the lower areas often receive natural subsidies).

Table 4.8: Different attributes of rangelands as inputs to ecological integrity

Attribute	Input to ecological integrity
Biodiversity Conservation	• Immense biodiversity of plants, animals and microorganisms varying according to altitude, slope-orientation, relief, rainfall pattern and other environmental factors; • Wild animals contribute to plant dispersal and energy and nutrient flows; • Conversion of solar energy into chemical energy through photosynthesis; • Contribution to ecosystem resilience and efficiency; • Response to the inherent fragility of the mountains; • An inherent ecosystem service vital for systemic linkages.
Soil and Water Conservation	• Conservation of the basic natural resources helps in enriching the very base of life activities in the habitat and in build up an environment suitable for ecological regeneration; • Circulation of moisture within and amongst ecosystems; • Maintenance of vital hydrological cycle; • Life imbibes in the soil also and it functions as a wonderful ecosystem; • Nutrient flows through soil and water as natural subsidy for other ecosystems in lower areas; • Contribution to temperature regulation and micro- and macro climate.
Food Chain and Food Web	• Various trophic levels imbibing with diversity of life thrive; • Unidirectional transfer of energy from the organisms of one trophic level to those of the other; • Ecosystem complexity is increased, which, in turn, enhances sustainability; • Nutrient cycling through the action of decomposers; • Energy and nutrient flows from rangeland to cropland via livestock contributing to sustainability of farming system.

Source: Adapted from Singh and Gautam (2005)

These forms of ecosystems – unlike the fossil fuel-powered ecosystems of the cities and industrial areas – demonstrate considerable resilience and are self-sufficient and sustainable. The cropland, on the contrary, can only be sustainable only when it constantly receives natural subsidy (nutrients in organic matter). Referred to as nature-subsidised solar-powered ecosystem, the cropland in a mountain agro-ecosystem is less resilient, more vulnerable and often attaining the very high degree of fragility.

Major attributes of rangelands to ecological integrity are summarized in Table 4.8. Ecological integrity, in essence, is function of the ecosystem services, such as conservation of biodiversity, soil and water, energy and nutrient flows through food chains and food web, etc. Ecosystem services are the inevitable products of ecological integrity. Integrated, cropland and rangeland ecosystems function as a single independent functional unit, the agro-ecosystem. Livestock provide a crucial dimension to this integrity. Isolated, the cultivated land would require inputs from the market system, as would be revealed in case of the food production systems under the umbrella of Green Revolution. Sustainability, in essence, is the function of this ecological integrity (Singh and Gautam 2005).

4.8.4 Rangeland utilisation for life-support activities

Rangeland ecosystems are utilised for a number of activities vital for livelihood systems in the mountain areas. The villagers – i.e., the livestock-depended farming community in the study area – have some preferences for the utilization of rangelands. People's preference ranking has been presented in Table 4.9.

Table 4.9: People's preference of rangeland utilisation

Use	Preference ranking	Species No.
Grazing	1	All palatable spp.
Fodder lopping	2	15
Fuel wood	3	6
Agricultural tools and implements	5	4
Medicine	9	9
Dyes	10	3
Fruits	11	5
Other edible products	6	7
Timber	8	3
Bedding material	4	5
Mulch	7	3
None-use value	Over and above	All available spp.

Rangelands' first and the foremost utilization is for grazing the livestock. Keeping livestock on grazing during daytime is one of the traditional and cost-effective ways of livestock production in the mountains as well as elsewhere. All types of land uses and virtually all palatable species available in the rangeland where livestock are to graze are utilized by livestock during the process of grazing. Fodder lopping is number two economic activity. All the fodder species available in the rangelands in an area are utilized for fodder lopping by the livestock owner. In our area of study as many as 15 species of fodder are utilized during different seasons of the year. Collection of bedding material to be used in the livestock sheds comes at number 4. There are five species people generally use for bedding material. The bedding material mixed with dung and converted into manure is eventually used for manuring the crop fields. Agricultural tools and implements are made of certain woody species occurring in the rangelands, which is the fifth preferable use of these ecosystems in the mountains. Four species are generally used for making agricultural tools and implements. Rangeland ecosystems are sources of several edible products. Collecting these products for consumption purpose is the sixth preference of the people. At number seven comes the use of rangeland-based species for mulch. Extraction of timber is the eight preferable economic activity of the people. Medicine, dyes and edible fruits come next in order in that sequence for which people depend on rangelands.

These uncultivated areas, in fact, have potential to provide more quality food per unit area on sustained basis than the cultivated land. People in the mountains have been extracting food (edible fruits, flowers, buds, seeds, vegetables, mushrooms, honey, etc.) from the forests/ rangelands for centuries. Rangelands are often appreciated for their contribution to the community of fuel, fodder, and timber. That they can provide the most basic necessity of humans, i.e., a variety of food items, is seldom appreciated. Singh (2004) has brought to the fore vital role of uncultivated forest areas for providing different food products to the community which is evident from his study in the Henwal Valley of Garhwal in Uttaranchal Mountains. In this Valley as many as 189 different naturally occurring species of plants offer edible products while people cultivate only 92 different food-producing plants on their cultivated land. Comparing this scenario with that of the plains' agriculture in the adjoining areas of the Garhwal Mountains, we would find that farmers

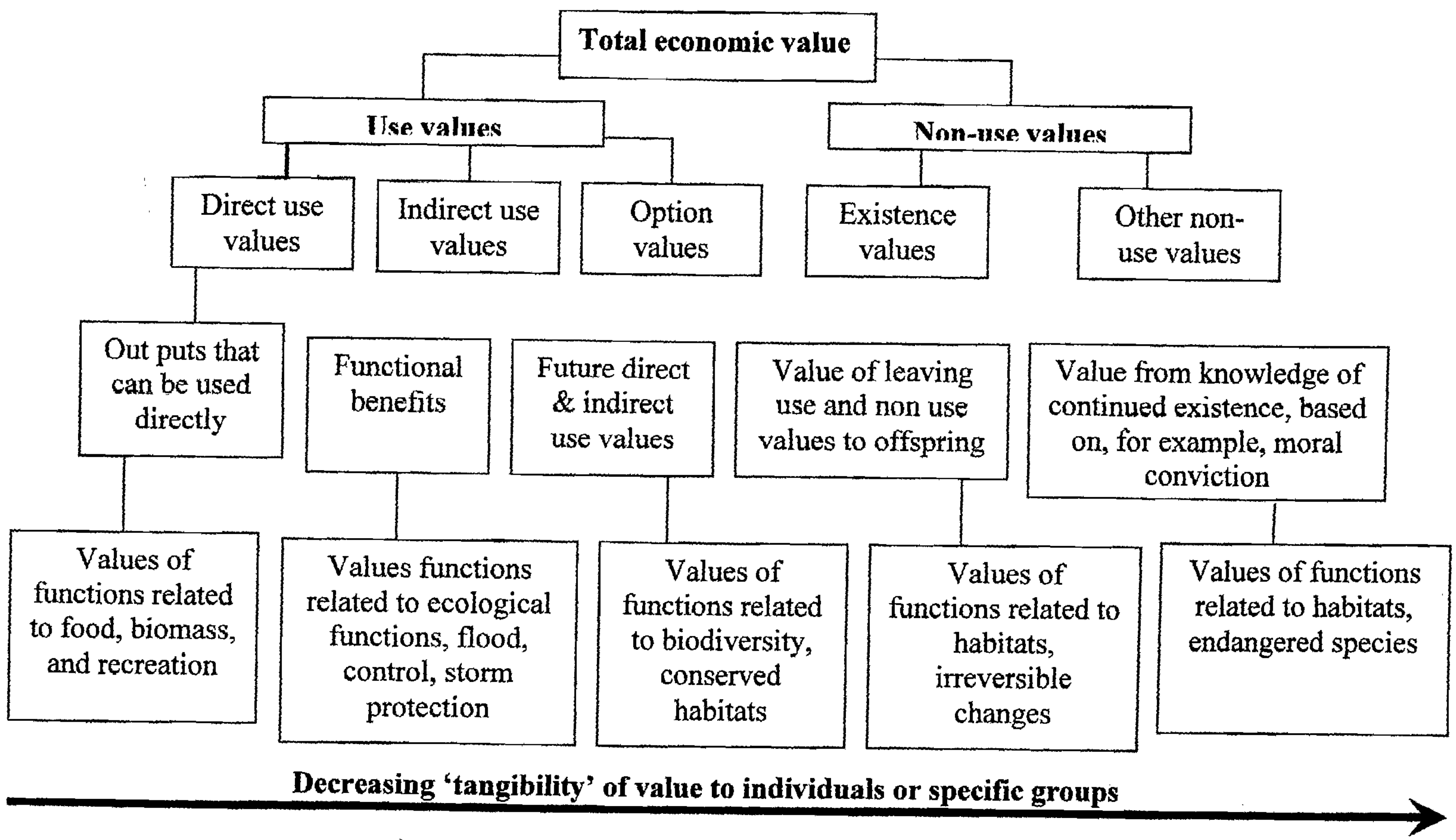


Fig. 5: The economic value of rangeland biodiversity (Source: Banskota 2004)

depend only on 33 plant species for their survival. Thus, from the point of view of plant species diversity offering food articles, rangelands are the richest sources.

Apart from several use values, there is also non-use values associated with rangeland ecosystems as indicated in Fig. 5. These values are over and above the direct use values. Banskota (2004) and Shiva et al. (2005) have illustrated the use and non-use values of several well-known and lesser known species in the mountain areas.

4.8.5 Primacy of rangeland management

Management of the natural resources in the Himalayan Mountains should be regarded not only essential but an imperative for restoring ecological balance and promoting livestock-based economic activities in the Region. Rangeland ecosystems also serve as biological corridors making continuous or near continuous link to a suitable habitat through an inhospitable environment. These ecosystems further serve as biological corridors linking the unique biodiversity-laden habitats between two or amongst many countries in the Himalayan Region (Zhaoli 2004).

There is considerable sharing of the range resources between two different areas and/ or state borders in India. For instance, Nomads would seasonally migrate with large number of domestic animals from Terai area to the alpine meadows in Uttaranchal. Nomads of Jammu and Kashmir would migrate to

Himachal Pradesh and those of Himachal Pradesh to Uttaranchal for the purpose of resource utilisation.

This migration is very natural and people involved do not face any legal barriers. Local communities in the Region accept the seasonal migrants and also often facilitate their movements along with their livestock. Management of natural resources by local communities thus also contributes to enhancing social-cultural cohesion amongst different tribes, nomads and transhumant communities.

Feed resources and appropriate habitat provided and ecosystem services rendered by the rangeland ecosystems are thus vital not only for livestock production, but also for livelihoods, ecosystem stability, sustainability and – consequently – for lasting peace and tranquility in the whole HKH Region. Ecological balance of the agro-ecosystems maintained through efficient management of the rangeland ecosystems is the key factor to strengthen the rangeland-dairy farming-livelihood linkages in the mountains.

4.9 Animal feed resources

Conventional animal husbandry practices in the less developed and developing countries largely built around the so-called White Revolution technology give more emphasis on cultivating fodder crops, and concentrates on arable land in order to increase animal production. Many regions of the world, however, do not spare considerable area for cultivation of fodder crops as part of animal husbandry. In India, for example, not more than four percent of the arable land is devoted to raising fodder crops. Smallholders comprising the majority of livestock farmers in the mountain areas prefer raising crops for their own consumption and are not in a position to make animals competent for the limited land they own. Only dry fodder (residue of food grain crops). Only crop residues and tree leaves (and occasionally weeds and green grasses during rainy season) from the agroforestry systems come from cultivated land. Even the large holders find cereal and other cash crops far more remunerative than the fodder crops. In the mountains they too do not raise livestock on cultivated fodders (Singh *et al* 1995).

It should also be realized that in many parts of India animals feed more on forest based fodders – trees, shrubs, grasses and other herbs – than on cultivated fodder. Mountain areas of Jammu & Kashmir, Himanchal Pradesh, Uttaranchal, Darjeeling district of west Bengal, Sikkim and Arunanchal Pradesh in the Indian Himalayas and hilly areas of North-East are such a region where uncultivated land (forest and grassland) are the main source of livestock feed.

For the purpose of convenience, there are two categories of land use systems – common property resources (CPRs) and private property resources (PPRs) – on which livestock owners depend for raising their livestock. CPRs include forest areas/ rangelands, particularly the Panchayat forests, marginal lands, and other spaces, such as roadsides, riversides, etc. PPRs include croplands (including agroforestry systems), private grassplots, homestead based fodders, kitchen wastes, etc.

Table 4.10: Main feed resources in the study area

Feed	Common property resources	Private property resources
Main trees/ Shrubs	Oak (*Quercus leucotrycophora*)	Bhimal (Grewia optiva)
		Kharik (*Celtis australis*)
		Bedu (*Ficus spp.*)
		Kuaral (*Bauhinia spp.*)
		Bakain (*Melia azaderach*)
		Tun (*Toona ciliata*)
Crop residues/ dry fodders	Grass hay	Wheat
		Paddy
		Barnyard millet
		Finger millet
		Pulses
Herbaceous plants	Grasses, palatable plants	Grasses on field bunds
		Weeds
Concentrate	-	Wheat flour
		Barnyard millets
		Finger millet flour
		Soybean
		Kitchen waste

4.10 Contribution of different feed sources

Crop residues and grass hay comprise the dry fodders fed to livestock. Crop residues of cereals and pulses are produced on private cultivated land while the grass hay comes from the enclosed areas in the rangelands.

It was estimated that on an average, some 82 percent of dry fodder in the form of crop residues is grown on cultivated land and only 18 percent comes as grass hay from rangelands. The cultivated land and the rangelands constitute private property resources (PPR) and common property resource (CPR), respectively. Maximum amount of dry fodder (30 percent) is contributed by wheat straw, followed by barnyard millet (18 percent), grass hay (18 percent), finger millet (16 percent), rice (14 percent), barley and pulses straw (about 2 percent each) (Fig. 6). Findings corroborate well with those of Singh (2000), Singh *et al.* (2001d) and Bohra and Singh (2005b). Millet straws, especially the barnyard millet straw, are the most preferred ones by the livestock farmers.

Mountain farmers overwhelmingly depend on CPRs for raising livestock. This is one of the unique features of mountain areas' land-based economies. Size of the holdings, therefore, is not a constraint to livestock husbandry in mountain areas as could be the case in the plains where CPRs have become redundant or a thing of the past. CPRs are the major source of green fodders – tree/ shrub leaves, green grasses and other herbaceous plants. PPRs provide bulk of the dry fodders in the form of crop residues. Tree/ shrub leaves, grasses from the field bunds and weeds extracted from the crop fields form greens available in the PPR-based land use.

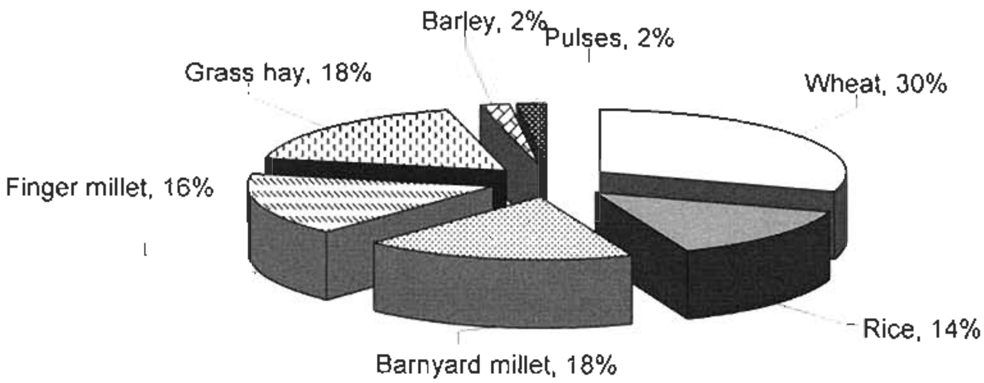


Fig. 6. Proportion of different sources of dry fodder in the mountains

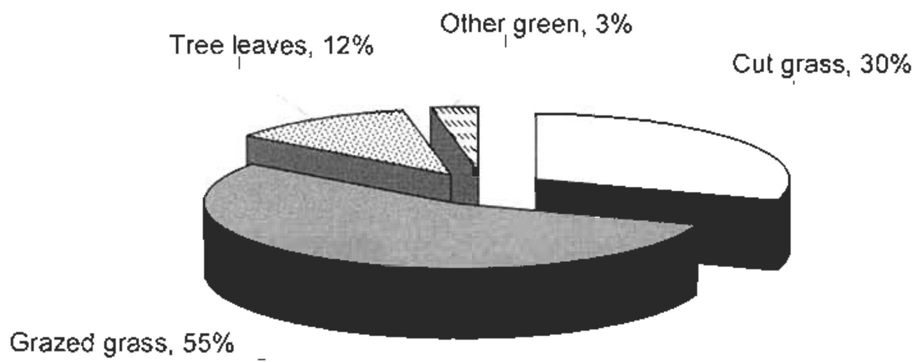


Fig. 7. Proportion of different sources of green fodder

Green grass (hand-cut) accounts for 30 percent of the total greens, while grazed grass as high as 55 percent. Tree leaves amounted to only about 12 percent. The other green comprising seasonal crops such as mustard, field weeds, etc. constitute about 3 percent of the total green fodder in a year, on an average (Fig. 7). While virtually entire grazed grass is the product of the rangelands, most of the hand-cut grass (including weeds growing in the fields) comes from the bunds of the terraced fields in the cultivated land area. Out of 12 percent biomass of tree leaves, about 5 percent comes from the rangelands and the rest from the croplands. Figures obtained in this study are in close proximity with those obtained by Singh (2000), Singh *et al.* (2001d) and Bohra and Singh (2005b)

Most of the concentrate feed utilized by dairy animals is home-produced. Barnyard millet, barley, white-seeded soybeans, black soybeans, wheat bran, wheat flour, etc. make the home-grown concentrate feed.

A dairy farm in a village dairy cooperative (VDC) will feed much more concentrates, both home-produced and purchased, to the dairy animals than its counter part in other villages. Proportion of the purchased feed is also the largest in a VDC village. Concentrate feeding per head per day is also higher in a VDC village, though it is far below the standards of dairy animal feeding (Bohra *et al.* 2005, Singh 2005).

4.11 Feeding practices

Provision of feeds and fodders to livestock in mountain areas would largely depend on the ecological zone a dairy farm is located in. the feeds and fodders presented in Table 4.8 are only those on which the dairy animals are largely dependent. Stinging nettle plant is given only during winter months, particularly to buffaloes. Concentrate mostly home- produced- is given throughout the year. It is generally given to milking animals only.

Table 4.10: Seasonal availability of fodders in the study area

Summer season	Rainy season	Winter season
Tree leaves		
Oak (*Quercus leucotrichophora*)	-	Betula (*Ficus clavata*)
Doodla (*Ficus nemoralis*)	-	Kwaral (*Bauhinia vahlii*)
Kimi	-	Bhimal (*Grewia optiva*)
Kharik (*Celtis australis*)	-	Kaul (*Machilus duthiei*)
Timal (*Ficus roxburghii*)	-	Oak (*Quercus leucotrichophora*)
Saujan *(Ougenia delbaegioides)*	-	Khinyo (*Ficus cunia*)
Kaul (*Machilus duthiei*)	-	Rampauren (*Vitis parkeri*)
Other green fodder		
Field weeds	Field weeds	Field weeds
-	-	Mustard (*Brassica* spp.)
-	-	Stinging nettle (*Urtica parviflora*)
Grasses/ Herbs		
Green grass	Green grass	
Gajao grass (*Themeda anathera*)	Gajao grass (*Themeda anathera*)	
Dry fodder		
Paddy straw	Wheat straw	Paddy straw
-	-	Mandua straw
-	-	Grass hay
-	-	Jhangora straw
Concentrate		
Home grown concentrate	Home grown concentrate	Home grown concentrate

Understanding of the fodder calendar is important for addressing the issue of seasonality of fodders associated with dairy production.

4.12 Feed supplementation experiments

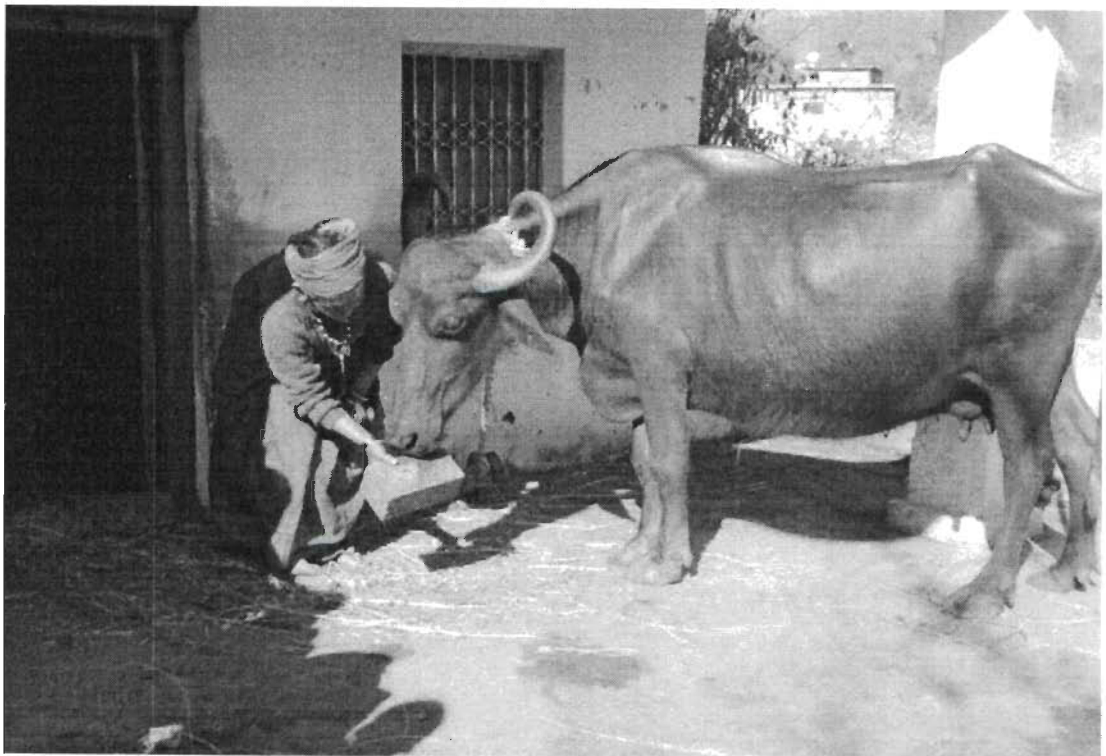
In the three selected villages, 64 cows and 32 buffaloes in the early stage of their lactation period were selected for the experiment. The experiment on the selected cows and buffaloes went on for five months (from October 2005 to

February 2006). The first month was used as adaptation period. The data were recorded for four months. The experimentation period fell in the span of the autumn and winter seasons. During this period some tree leaves, mustard and field weeds comprised the green fodder the proportion of which changed on the field on daily basis. The green was used simply as a supplement. There were several days when the green was not provided to the animals at all.

In the winter season, grass hay and straws of finger millet, barnyard millet and paddy were the main dry fodders. There proportion varied from time to time depending on the availability of a particular fodder.

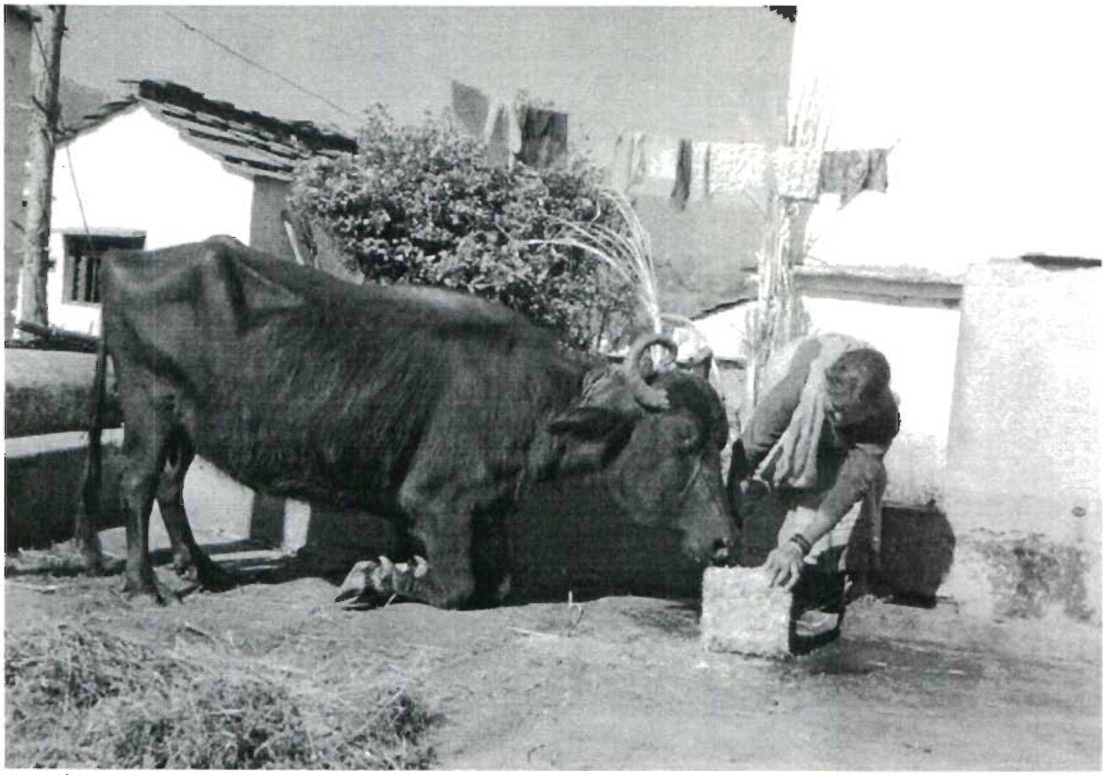
Concentrate prepared from locally produced ingredients was supplemented to the lactating animals. Composition of the concentrate, locally called as *chata* was as follows: black soybeans 10%, soybeans 15%, barnyard 10%, gram 5%, wheat 45%, barley 10% sugar or jaggery 5%. Rate of concentrate supplementation is not fixed. Approximately half a kg of concentrate is provided to a lactating cow per day, half of it in the morning and half in the evening minutes before milking time. About the double of it is provided to a lactating buffalo in the same fashion.

The cows were kept on daytime grazing while buffaloes were fed exclusively on stall. Grazing length of cows was about five hours per day. They are allowed to graze in the adjacent rangelands, fallow fields or on roadside near the villages. Nutritive values of the feeds are presented in Table 4.16.

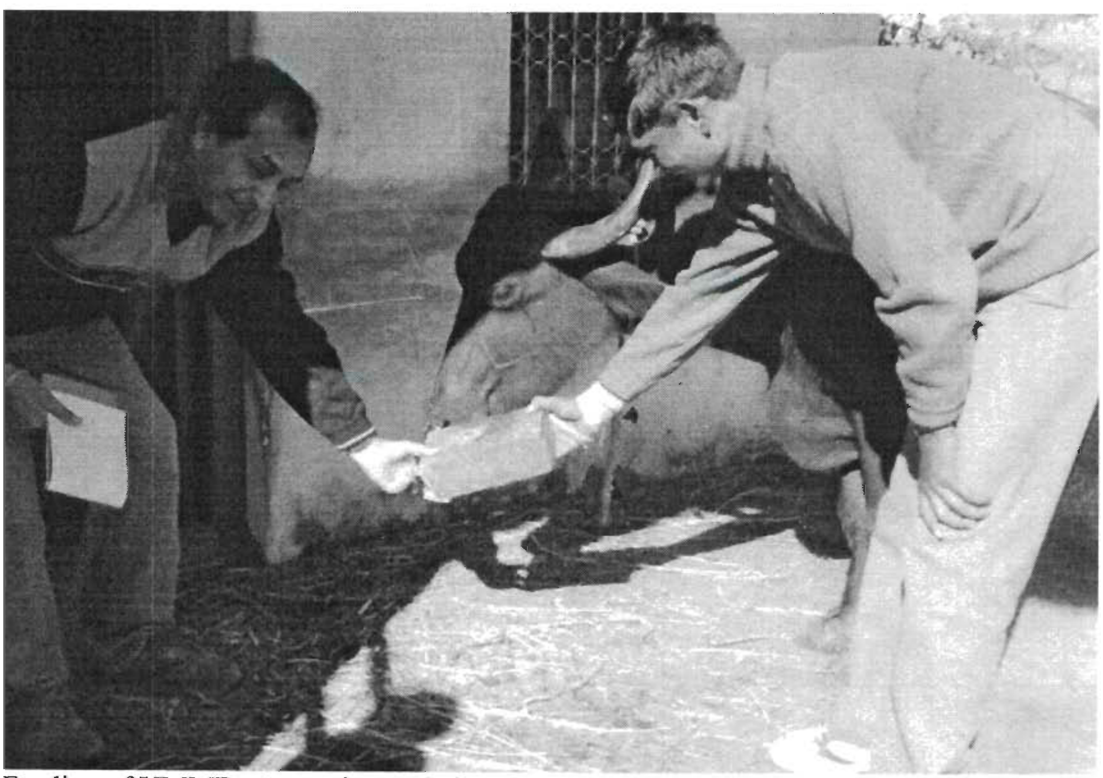


Supplementary feeding of UMMB at experimental site

Feeding of UMMB at experimental site

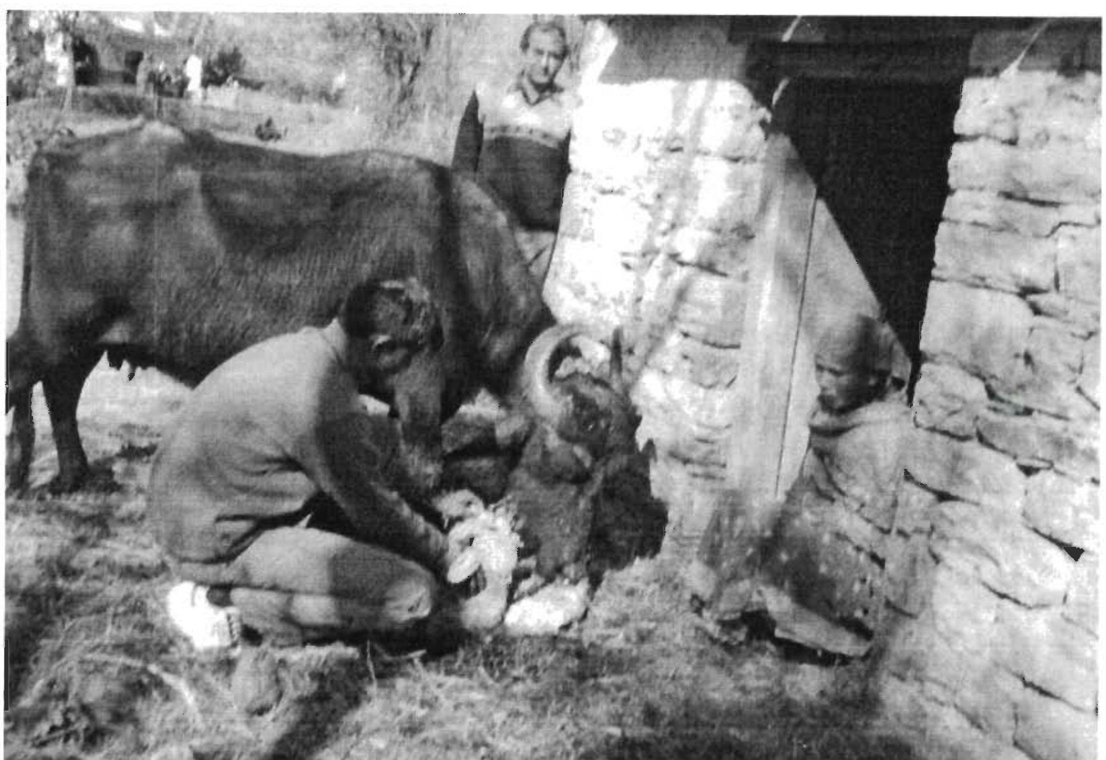


Feeding of CFB at experimental site



Feeding of UMMB at experimental site

Feeding of complete feed block at experimental site



Feeding experimental diet the traditional way

4.12.1 Supplementation of CFB

The complete feed block was fed to the dairy animals supplemented with local diet. Approximately 1.5 to 2.0 kg was fed to a cow per day and about 2.5-3.0 kg per day to a head of buffalo. Farmers did not weigh the supplement before supplementing it with diet. It was either mixed with the traditional diet or fed exclusively often twice a day. The composition (in percentage) of the CFB supplemented with the usual diet of the selected dairy animals was as follows:

Wheat straw	43
Concentrate	45
Urea	01
Molasses	07
Common salt	01
Binding	03
Total	100

While there is no manger system for feeding the dairy animals in the area due to which lot of feed wastage occurs, CFBs were fed kept in some kind of containers. However, many farm families did not obey this rule.

4.12.2 Supplementation of UMMB

Fodder bank at the Pantnagar University recommends one UMMB weighing 4.0 kg to be used for licking a cow so that it is completely consumed within a week. Given the lower weight of a hill cow (almost half of its counterpart in the plains), the farmers were advised to allow the licking of a UMMB by a cow so that it was consumed within two weeks. A buffalo was allowed to lick a UMMB within a week. The UMMB was placed in a container in front of a dairy animal. The licking was done often twice a day before milking the animal. While the farmers were given informal demonstration of UMMB supplementation and feeding, they did not always adhere to the advice.

Composition of UMMB in percentage was as follows:

Molasses	40
Urea	08
Concentrate mixture	35
Mineral mixture	06
Common salt	04
Binding agent	07
Total	100

4.12.3 Effect of feed supplementation on milk production

The animals selected for on-farm experiment were divided into four groups each of lactating cows and buffaloes as follows:

T1: dairy animals fed local diet,

T2: dairy animals fed local diets supplemented with CFB, T3: dairy animals fed local diet supplemented with UMMB, and

T4: dairy animals fed with local diet supplemented with CFB and UMMB

Average milk production of T1, T2, T3, and T4 group animals was 2.25±0.16, 2.69±0.16, 2.80±0.16 and 3.31±0.16 kg respectively in cows and 4.50±0.27, 4.88±0.27, 5.00±0.27 and 6.00±0.27 kg in buffaloes, respectively. Percent increase in milk production over T1 was highest in the T4 group both in cows and buffaloes (47.11 and 33.33 percent respectively). T3 group recorded 24.44 and 11.11 percent increase in milk production over T1 in cows and buffaloes respectively, while T2 group witnessed only 19.55 and 8.44 percent increase in milk production over T1 in cows and buffaloes, respectively. The effect of supplemented nutrients, thus, was more in cows kept on grazing than on the buffaloes fed on stall. There was significant increase in production ($P<0.01$) of T2, T3 and T4 groups in comparison to T1 group both in cows and buffaloes. There was no significant difference in milk production between T1 and T2, T2 and T3 but there was the significant difference between T1 and T3, T1 and T4, T2 and T4 in cows. In case of buffaloes there was the significant difference between T1 and T4, T2 and T4, T3 and T4 but not significant difference between T1 and T2, T1 and T3, T2 and T3. The supplementation of both UMMB and CFB in milking cows and buffaloes ration had contributed to significant increase in milk yields of both the species of dairy animals (Table 4.11).

Only little efforts have been made towards supplementing such external feeds in mountain areas. Singh (2000), Bohra (2003) and Singh and Bohra (2006) have recorded that external feed supplements are provided to dairy animals only by the farmers who are the members of the Village Dairy Cooperatives (VDCs) or by a handful farmers in the peri-urban areas.

Table 4.11: Effect of feeding complete feed block (CFB) and urea molasses mineral block (UMMB)-supplemented diets on milk production of cows and buffaloes

Particulars	T1	T2	T3	T4	Cd 5%
Cows**	2.25^{a}±0.16	2.69^{ab}±0.16 (19.55)	2.80^{b}±0.16 (24.44)	3.31^{c}±0.16 (47.11)	0.45
Buffaloes**	4.5^{a}±0.27	4.88^{a}±0.27 (8.44)	5.00^{a}±0.27 (11.11)	6.00^{b}±0.27 (33.33)	0.79

** Significant increase P<0.01
Figures in parentheses are percentage increase in milk production over T1.
Values bearing different superscripts in a row differ significantly, *P<0.05
T1: dairy animals fed local diet
T2: dairy animals fed local diets supplemented with CFB
T3: dairy animals fed local diet supplemented with UMMB
T4: dairy animals fed with local diet supplemented with CFB and UMMB

Singh *et al.* (2004) experimented on large number of dairy animals in the two blocks of Uttaranchal, viz., Narendra Nagar in Garhwal and Tarikhet in Kumaun. They supplemented the diets with UMMB and observed that the milk production was significantly increased as a result of the supplementation of the external nutrients. Their observations corroborated with those of the present experiments.

UMMB used for licking by livestock would be an appropriate feed supplementation strategy for mountain areas. This practice prevents prevent diseases/ physiological abnormalities borne out of mineral deficiencies prevailing in the region and takes care of rumen ecology so vital for the health of ruminant livestock (Singh 2002b).

4.12.4 Economic evaluation of CFB and UMMB supplementation

Economic evaluation of CFB and UMMB supplementation was done by considering the daily supplementation cost of CFB and UMMB and income generated from increased milk yield. Cost of the feed supplements was:

UMMB @ Rs. 6.75/ kg
CFB @ Rs. 4.00/ kg
Buffalo milk @ 14.00/ kg
Cow milk @ 12.00/ kg

The following formula was used for calculation of net profit per animal per day:

Net profit (Rs.) = Cost of extra milk yield – cost of UMMB/ CFB intake by animal

Since the extra income accrued to the farmers was on the basis of the comparison with traditional pattern of feeding, other costs normally included in economic analysis were not taken into consideration. It was noted down that the farmers did not try to save on the home-produced concentrate they were feeding their lactating animals in their traditional feeding practices. The concentrate was fed as such despite the supplementation of the CFB and UMMB. It was also a fact that due to improved palatability and increased digestibility of the overall diet of the lactating animals under experiment, extra feed was consumed by the animals. Cost of this extra feed (only the dry and green fodder) was also not involved in the economic analysis. It was assumed that the local feeds which were wasted under the traditional feeding system were saved to some extent by slight change in the feeding practice of the experimental animals. Only the extra income generated through extra milk produced as a result of feed supplementation and the cost of the supplemented feed was taken into account.

Economic evaluation of daily feeding of CFB and UMMB per cow/ buffalo and during the experiment period (Table 4.12) revealed that average increase in milk yield was 0.44 l/ day, 0.55 l/ day and 1.06 l/ day in T1, T2 and T3 groups in cows respectively, and incase of buffaloes milk production was 0.30 l/ day, 0.50 l/ day and 1.50 l/ day in T1, T2 and T3 groups respectively. The increase in milk yield of cows and buffaloes due to CFB and UMMB supplementation during four months was significant.

The net income from the CFB and UMMB supplementation in cows and buffaloes during the trial period was computed as difference of total income from extra milk and cost of CFB/ UMMB. The daily net income per cow was estimated as Rs. -0.96, Rs. 4.67 and Rs. 4.55 in T2, T3 and T4 groups respectively. It means that the group fed CFB did record a marginal loss of income. It was due to the fact that the cost of CFB could not be compensated by proportional increase in milk production.

Income through buffalo milk was Rs. -6.20 in T2, Rs. 3.15 in T3 and Rs. 6.75 in T4 groups. The average net income per day was higher in T4 (UMMB+CFB) and lower in T2 (CFB). Considerable loss in net income was recorded when the buffaloes were fed on supplemented CFB. Cost of CFB could not compensate due to increased milk production. Hence the loss was recorded.

Table 4.12: Economic evaluation of feeding complete feed block (CFB) of cows and buffaloes (T2)

Particulars	T1		T2		T3		T4	
	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes	Cows	Buffaloes
Extra milk yield per day	0.00	0.00	0.44	0.30	0.55	0.5	1.06	1.50
Cost of daily CFB intake (Rs)	-	-	6.24	10.40	-	-	-	-
Cost of daily UMMB intake (Rs)	-	-	-	-	1.93	3.85	-	-
Cost of daily CFB + UMMB intake (Rs)	-	-	-	-	-	-	8.17	14.25
Cost of extra milk yield (Rs.)	-	-	5.28	4.2	6.6	7.00	12.72	21
Net income	0.00	0.00	-0.96	-6.2	4.67	3.15	4.55	6.75

Price list: Cow milk @ Rs. 12.00/ lt., Buffalo milk @ Rs. 14.00/ lt., complete feed block @ Rs. 4/ kg (4 % tax) UMMB @ Rs. 6.75
T1: dairy animals fed local diet,
T2: dairy animals fed local diets supplemented with CFB,
T3: dairy animals fed local diet supplemented with UMMB,
T4: dairy animals fed with local diet supplemented with CFB and UMMB

Singh *et al.* (2004) found the overall net income in the selected pockets in Uttaranchal mountains equals to Rs. 2.95 per cow/ day and Rs.4.07 per buffalo/ day. They concluded that the net income from UMMB supplementation in both cows and buffaloes was significant.

4.13 Diversity of fodder species in the rangeland ecosystems

The rangelands which were covered for this study were located at mid-altitudes in the Lohaghat area in district Champawat which is situated towards the easternmost part of Uttaranchal. The altitude on which the rangelands were lying ranged between 1500 – 2000 masl. The rangelands studied were oak types, chirpine types, grass types and mixed ones.

More than 150 species of grasses, other herbaceous species, trees and shrubs were found in the mid-altitude rangelands in the mountains of Uttaranchal (Table 4.13). This variety of fodders available in the rangelands is amazing particularly when no more than a dozen fodder species are conventionally referred to and recommended (Singh *et al.* 1995).

Table 4.13: Diversity of the fodder species in the rangeland ecosystems

Botanical name	Family
Acacia mimosoides	Caesalpinaceae
Achyranthes bidentata	Amaranthaceae
Adhatoda vasica	Acanthaceae
Agrimonia pilosa	Rosaceae
Agrostis pilosa	Poaceae
Agropyson longiaristalum	Poaceae
Agrostis giganter	Poaceae
Anaphalis cinnamomum	Asteraceae
Apluda nutica	Poaceae
Artemisia nilagirica	Asteraceae
Artemisia parviflora	Asteraceae
Arthraxon lanciflolius	Poaceae
Arthraxon prionoides	Poaceae
Arundinella nepalensis	Poaceae
Aster molliusculus	Asteraceae
Basella rubra	Basellaceae
Bauhinia vahlii	Caesalpinaceae
Betula alnoides	Betulaceae
Bidens pilosa	Asteraceae
Boehmeria platyphylla	Vrticaceae
Boenninghausenia alba	Rutaceae

Brachypodium sylvaticum	Poaceae
Bupleurum hamiltonii (tenue)	Apiaceae
Capillipedium assamilis	Poaceae
Capillipedium parviflorum	Poaceae
Carex cruciata	Cyperaceae
Cassia tora	Caesaepiniaceae
Celtis australis	Urticaceae
Chenopodium ambrosioides	Chenopodiaceae
Chrysanthemum leucantheum	Aseraceae
Chrysopogon gryllus	Poaceae
Cinnamomum tamala	Lauraceae
Clematis buchananiana	Ranunculaceae
Commelina benghalensis	Commelinaceae
Cornus oblonga	Cornaceae
Cuscuta reflexa	Convolrulaceae
Cynodon dactylon	Poaceae
Cyperus monocephala	Cyperaceae
Cyperus nutans	Cyperaceae
Cyperus rotundus	Cyperaceae
Dactyloctenum aegyptium	Poaceae
Dicanthium annulatum	Poaceae
Dicliptera bupleuroides	Acanthaceae
Digitaria cruciata	Poaceae
Digitaria granularis	Poaceae
Digitaria stricta	Poaceae
Dioscorea bulbifera	Dioscoreaceae
Dioscorea kumaonensis	Dioscoreaceae
Drymaria cordata	Caryophyllaceae
Echinochloa crusgalli	Poaceae
Echinochloa crusgalli	Poaceae
Echinochloa frumentacea	Poaceae
Eigeron karvinskianus	Asteraceae
Eleusine indica	Poaceae
Eragrostis gangetica	Poaceae
Erigeron annuus	Asteraceae
Erigeron bonariensis	Asteraceae
Erigeron Canadensis	Asteraceae
Erigeron karvinskianus	Asteraceae
Eupatorium adenophorum	Asteraceae
Eurya acuminate	Ternstraemiaceae
Fagopyrum dibotryx	Polygonaceae
Ficus capreolata	Vitaceae
Ficus clavata	Moraceae
Ficus cunia	Moraceae
Ficus nemoralis	Moraceae
Ficus palmate	Moraceae
Ficus roxburghii	Moraceae
Flemingia strobifera	Fabaceae

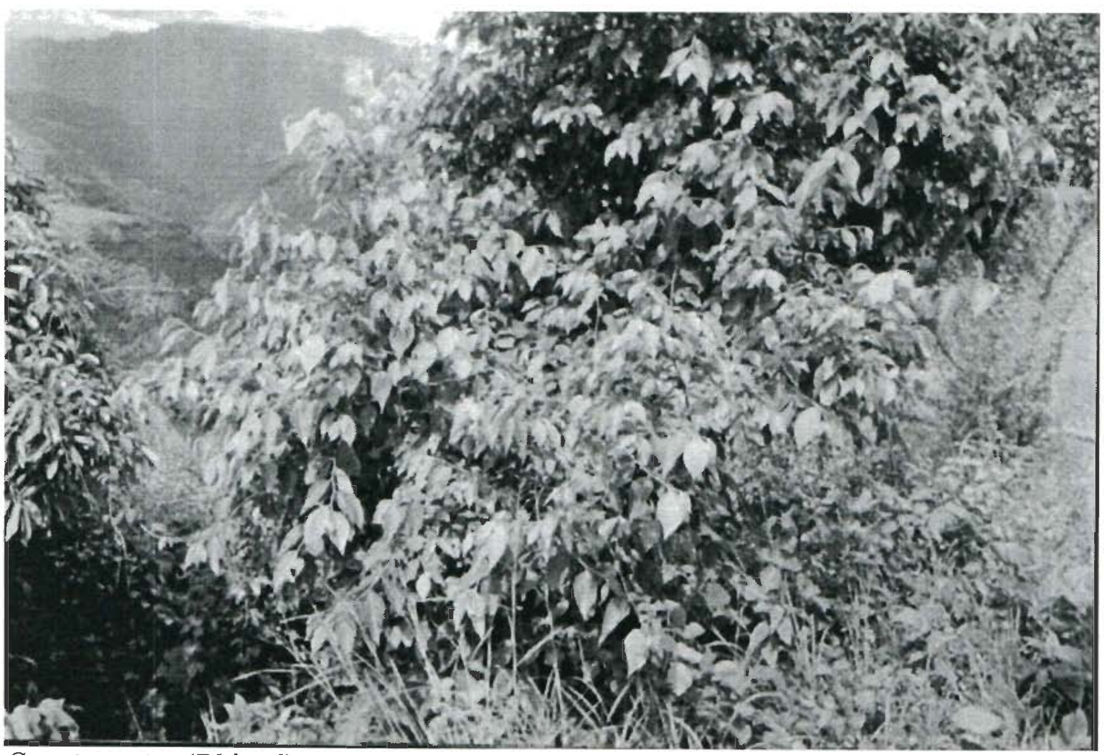
Fleningia semialata	Fabaceae
Fraximus micrantha	Oleaceae
Galinsoga parviflora	Asteraceae
Gallium rotendifolium	Rubiaceae
Geranium wallichianum	Geraniaceae
Gomphena celosioides	Amaranthaceae
Grewia optiva	Tiliaceae
Gymnostemma pedata	Cucurbitaceae
Hedychium spicatum	Zingiberaceae
Hymenodactyon suaveolens	Rubiaceae
Impatiense scabrida	Balsaminaceae
Imperata cylindrical	Poaceae
Indigofera dosua	Fabaceae
Ipomoea muricata	Convolvulaceae
Isachne pulchella	Poaceae
Justicia simplex	Acanthaceae
Leonurus cardiaca	Laminaceae
Leptadermis lanceolata	Rubiaceae
Leucas lanata	Lamiaceae
Lindenbergia indica	Scrophulariaceae
Lomicera quinquelocularis	Caprifoliaceae
Machilus duthiei	Lauraceae
Miscanthus nepalensis	Poaceae
Morus alba	Moraceae
Muehlenbergia hugely	Poaceae
Myrsine Africana	Myrsinaceae
Nicandra physalodes	Solanaceae
Oplismenns compositus	Poaceae
Oplismenus burmannii	Poaceae
Origanum vulgare	Lamiaceae
Ougeinia dalbaegioides	Fabaceae
Oxalis corniculata	Oxalidaceae
Oxalis dehradunensis	Oxalidaceae
Panicum psilopodium	Poaceae
Panicum spp.	Poaceae
Parthenocissus himolayana	Vitaceae
Paspadium paspaliodes	Poaceae
Passiflora caerulch	Passifloraceae
Pennisetum flaccidum	Poaceae
Pimpinella acheilliflia	Apiaceae
Pimpinella diversifolia	Apiaceae
Pistacia integerrima	Sapindaceae
Plantago lanceolatum	Planaginaceae
Plectranthus japonicus	Lamiaceae
Poa annua	Poaceae
Poa pretense	Poaceae
Pollinia quadrinervis	Poaceae
Polygonum capitatum	Polygonaceae

Polygonum hydropiper	Polygonaceae
Populus ciliate	Solinaceae
Pteris cretica	Pteridiceae
Pupalia lappacea	Amaranthaceae
Quercus leucotrichophora	Fagaceae
Quercus semecorpifolia	Fagaceae
Rhus semialata	Anacardiaceae
Rhus wallichii	Anacardiaceae
Rubia cordifolia	Rubiaceae
Rubus ellipticus	Rosaceae
Rubus paniculatus	Rosaceae
Rumex hastatus	Polygonaceae
Saccharum filiformis	Poaceae
Saccharum rifipilum	Poaceae
Salvia leucantha	Lamiaceae
Setaria homonyma	Poaceae
Seteria homonyma	Poaceae
Smilax aspera	Smilacaceae
Solanum nigrum	Solenaceae
Sonchus brachyotus	Asteraceae
Sorghum helepense	Poaceae
Sotaria glauca	Poaceae
Sporobolus diandra	Poaceae
Strotilenthes atropurpureas	Acanthaceae
Swertia angustifolia	Geniniaceae
Taraxacum officinalis	Asteraceae
Thalictrum foliolosum	Ranunculaceae
Themeda anathera	Poaceae
Thymus syrphyllum	Lamiaceae
Toona ciliate	Meliaceae
Torena cordifolia	Scrophulariaceae
Trifolium repens	Fabaceae
Tripogon filiformis	Poaceae
Trychosanthes palmate	Cucurbitaceae
Urena labata	Malvaceae
Urtica parviflora	Urticaceae
Viburnum coriaceum	Caprifoliaceae
Vitis parkeri	Vitaceae

Singh *et al.* (1995) and Singh and Bohra (2005) have given the list of 50 fodder trees, shrubs and non-graminaceous herbaceous plants occurring in mountain habitats. These fodder species occur in the agro-forestry systems or in the tree-dominated rangelands.

As is clearly revealed from the exhaustive list of fodder plants presented in Table 4.13, most of the plants constitute grasses belonging to Poaceae (Gramineae) family. The grass type rangelands especially harbour a variety of grass species. Several types of grass covers occur in the areas. Dabadghao and Shankarnarayan (1973) described five major types of grasslands in India out of which two types, viz., *Themeda-Arundinella* (500-2500m) and temperate alpine zones (above 2500 m), were recorded in the Himalayas. In the Western Himalaya, *Cenchrus ciliaris*, *Cynodon dactylon*, *Bothriochola pertusa* grass cover is dominant up to 500 m elevation. The zone between 500-2500 m is dominated by *Chrysopogon fulvus*, *Themeda anathera*, *Arundinella nepalensis* and *Heteropogon contortus*. Other common grasses in this zone are *Eulaliopsis binata*, *Chryspogon gryllus*, *Muhlenbergia duthieana*, *Cymbopogon strachevi*. *Bromus ramosus*, *Dictylis gloomerata* and *Oryzopsis acquiglummis*. Regions above 3300m were represented by *C. gryllus*, *Poa annua* and *Agrostis cannia*. Agarwal (1959) reported 4 grasslands types in the chakrata forest division of Dehradun district. Gupta (1974) has described 9 types of grass covers from the Central Himalayas (Garhwal Himalaya). Numata (1983) and Tsuchida (1983) reported that *Dactyloctenium aegyptium*, *Chrysopogon acicculatus*, *Cynodon dactylon*, *Imperata cylindrica*, *Paspalum serobiculatum*, *Cyperus rotundus*, *Arundinella*, *Dycanthium*, *Setaria Pallidefusca*, *Arthraxon quartinianus*, *Eragrostis*, *Panicum* and *Paspalidium* species of grasses were common on sub-tropical and temperate zones of the eastern Nepal. Also in road sides on steep slopes, a few grass communities occur. However, grass species were found in all kinds of vegetations. About 250 species of Western, Central and Eastern Himalayas were presented by

Vitis pakeri (Rampauren)



Grewia optiva (Bhimal)

Machilus duthiei (Kaul) in a well managed rangeland

Ficus clavata (Betula)

Quercus leucotrichophora (Oak): A symbol of ecological and socio-economic prosperity and posterity of life in the Himalayan mountains

Grass-conifer type rangeland

Grass type rangeland

Rangeland on abandoned cultivated area

Mixed forest ecosystem as a backbone for mountain agriculture and livelihoods

Grass protected in a rangeland for rich harvest followed by hay making

A mixed type rangeland is always more stable and more promising

A rangeland assuring soil protection

A rangeland as a rich repository of species of graminae family

Oak type forest ecosystem as a cornucopia of socio-economic and ecological attributes

A well protected grass-dominated rangeland

Patil and Pathak (1980). When the grasslands are subjected to grazing on burning, a variety of grassland types developed which vary in successional status (Gupta and Nanda 1970, Dabadghao and Shankarnarayan 1973, Gupta 1974, Patil and Pathak 1980, Numata 1983, Tsuchida 1983, Sundriyal *et al.* 1987, Singh and Gupta 1993).

Species composition of the grassland at highest stage of progression includes most productive and nutritious species. However, with increasing biotic pressure, vegetation cover reduced significantly (Singh 1991).

It is revealed that livestock graze selectively on some species and they prefer nutritious forbs (Gupta 1986, Sundriyal and Joshi 1992), and thus unpalatable species proliferate in the grassland. Yadava and Singh (1977) argued that succession in grasslands often intimately associated with grazing pressure. It can be concluded that multitude of factors, i.e. altitude, slope, aspect, canopy cover, soil types, biotic pressure and successional status determine the grassland composition in any area, and extent of these factors vary from place to place (Patil and Pathak 1980, Sexena and Singh 1980, Singh and Sexena 1980, Melkania 1983, Melkania and Tondon 1983, Gupta 1986).

4.14 Vegetational analysis of herbaceous layer in rangelands

This anaysis done in the grass type rangelands involves only the grminaceous and non-graminaceous herbaceous plants of crucial fodder value. The sites were dominated by grasses. Vegetative propagation, easy dispersal of seeds by animals, livestock grazing pressure and human management are the main reasons for the dominance of grass species in the rangeland ecosystems. *Themeda anathera* had the highest density of 72.5 per m^2, while *Acacia mimosoides* with the least density of 0.5 per m^2 (Table 4.14).

Table 4.14: Vegetational analysis of herbaceous layer of the rangelands

Species	Density (per m^2)	Frequency (F) (%)	Abundance (A)	A/F	IVI
Themeda anathera	72.5	60	120.83	2.01	43.32
Digitaria striata	32.4	50	64.8	1.29	23.04
Pennisetum flaccidum	20.2	50	28.4	0.56	14.99
Seteria homonyma	20.2	70	28.85	0.41	17.14
Erigon karvinskianus	15.5	20	77.5	3.87	15.84
Echinochloa crusgalli	15.2	40	38	0.95	13.4
Elusine indica	14.2	50	28.4	0.56	13.05
Chrysopogon gryllus	13.0	30	43.33	1.44	12.23
Eragrostis gangetia	10.5	30	35	1.16	10.48
Cyprus rotundus	10.2	40	25.5	0.63	10.37
Sporobolus diandra	8.2	20	41	2.05	9.37
Oplismenns compositus	7.2	50	14.4	0.28	9.2
Arundinella nepalensis	7.2	40	18	0.45	8.55
Digitaria cruciata	7.0	50	14	0.28	9.09
Cynodon dactylon	5.5	20	27.5	1.37	6.96
Miscanthus nepalensis	5.0	40	12.5	0.31	7.22
Chenopodium ambrosioides	4.5	30	15	0.5	6.29
Agrostis pilosa	4.5	30	15	0.5	6.29
Cyperus nutans	4.5	10	45	4.5	7.57
Achyranthes bidentata	4.2	30	14	0.46	6.07
Pollinia quadrinervis	4.2	10	42	4.2	7.13
Dactyloctenum aegyptium	4.0	30	13.33	0.44	5.94
Justicia simplex	3.6	10	36	3.6	6.26
Brachypodium sylvaticum	3.5	30	11.66	0.38	5.59
Arthraxon prionoides	3.0	20	15	0.75	4.76
Leucas lanata	2.8	10	28	2.8	5.1
Oxalis corniculata	2.6	20	13.00	0.65	4.59
Rumex hastatus	2.0	30	6.66	0.22	4.54
Dicanthium annulatum	1.2	10	12	1.2	2.78
Acacia mimosoides	0.5	20	2.5	0.125	2.54

Themeda anathera was the dominant grass in the rangelands of the study areas with highest importance value index (IVI) of 43.32 followed by *Digitaria* *striata, Pennisetum flaccidum, Seteria homonyma, Erigon karvinskianus, Echinochloa crusgalli, Elusine indica, Chrysopogon gryllus, Eragrostis gangetia, Cyprus rotundus, Sporobolus diandra, Oplismenns compositus, Arundinella nepalensis, Digitaria cruciata, Cynodon dactylon, Miscanthus nepalensis, Chenopodium ambrosioides, Agrostis pilosa, Cyperus nutans, Achyranthes bidentata, Pollinia quadrinervis, Dactyloctenum aegyptium, Justicia simplex, Brachypodium sylvaticum, Arthraxon prionoides, Leucas lanata, Oxalis corniculata, Rumex hastatus, Dicanthium annulatum* and *Acacia mimosoides.*

The grasses present mainly coarse and sedges. *Selaginella chrysocaulos* is found mainly under the canopy of *Quercus leucotrichophora*. In this site *Themeda anthera* had the highest density as found out by Bhatt (2005).

The results were attributable to different observations which were recorded by different scientists; the temperate grasslands are the characteristic of the oak – conifer forest region where the soil is deep and moist. Stable grasslands occur due to the misuse of forest vegetation. Animals are allowed to graze in these grasslands during winter season also (Gupta and Nanda 1970). The study area was typically cataract in the temperate grasslands the dominating grasses were *Chrysopogon montanus, Cymbopogon spp. Dichanthium annulatum, Heteropogon contortus and the anathera. Agropyron longearistatum, A. semicostatum, Arundinella nepalensis. A. setosa, Bromus asper, Cenothecalappacea, Cymbopogon distans, Digitaria ischaemum, Mùhlenbergia huegelii, Oplismenus compositus, O. undulatifolus, Oryzopsis* *aequiglumis, Panicum psilopodium, Pennisetum flaccidum, P. orientale, Poa pratensis and Tripogon filiformis.*

A number of forest types occur in the Himalayas, which are distributed widely with the gradient of elevation from subtropical to temperate and alpine zones (Champion and Seth 1968, Singh and Singh 1992). With increasing pursuing fuel and fodder on these forests, a variety of grassland types are developed particularly on mid-hills (Yadav and Singh 1977, Melkania and Singh 1989). In alpines, however, natural grasslands occur. All these grasslands were maintained by grazing, mowing and burning (Dabadghao and Shankarnarayan 1973). In the Himalayas, large share of economy of the hill people is mainly dependent on livestock and its products, and the huge livestock populations rely on the grasslands and forests for the fodder (Gupta 1986).

4.15 Herbage productivity in the different rangelands

The average herbage productivity values in different rangelands – viz., oak type, mixed type, oak-grass type, oak-conifer type and grass type – were 121.64±12.92g/ m^2, 78.09±16.19g/ m^2, 153.64±23.89g/ m^2, 128.88±20.66g/ m^2 and 106.00±10.52g/ m^2 respectively in summer season. In rainy season productivity was more in comparison to the summer season, which was recorded to be 501.28±66.65g/m^2, 763.20±12.88 g/ m^2, 454.68±27.05 g/ m^2, 692.12±81.48 g/ m^2 and 766.88±23.07g/ m^2 in oak type, mixed type, oak-grass type, oak-conifer type and grass type rangelands correspondingly. Highest productivity was recorded in oak-grass type rangeland in summer season and grass type in rainy season. Herbage productivity was low in summer season and high in rainy season, which was due to the environmental factors which were unfavourable for plant growth during summer season (Table 4.15).

Table 4.15: Herbage productivity per m^2 in different rangelands in the study areas during summer season and rainy season

Type of rangeland	Average productivity g per m^2 in Summer season	Average productivity g per m^2 (g) in Rainy season
Oak type	121.64 ± 12.92	501.28 ± 66.65
Mixed type	78.096 ± 16.19	763.20 ± 12.88
Oak + grass type	153.64 ± 23.80	454.68 ± 27.05
Oak+ conifer type	128.88 ± 20.66	692.12 ± 81.48
Grass type	106.00 ± 10.52	766.88 ± 23.07

According to Sundriyal (1995) the productivity of the herbage was influenced by the great seasonality of climate, and biotic pressure on them. Grasslands and forest grazing lands meet about 50-60% of total fodder need in the Himalayas; however, their composition and net primary productivity vary from area to area due to the variation in the species dominance, topography, rainfall pattern, biotic pressure and successional status of grasses.

4.16 Chemical composition and nylon bag digestibility of different feeds

The samples collected from the fields were immediately weighed and brought to the lab for their chemical analysis. The collected samples were divided into four groups of samples, namely, tree leaves (G1), grasses (G2), crop residues

(G3) and experimental feeds (G4). This categorization was convenient since it was according to the category of feeds.

4.16.1 Dry matter (DM)

As revealed through Table 4.16, there was a wide variation in chemical composition and nylon bag dry matter digestibility of different samples. Average DM content was 36.07±2.88, 36.24 ± 12.44, 89.30±0.59 and 87.13±3.62% in tree leaves, grasses, crop residues and experimental feeds respectively (Table 4.17). Dry matter content varied from 10.58% (*Vitis parkeri*) to 93.70% (locally prepared concentrate, *Chaata*) in different groups. Among tree leaves, DM percentage was high in *Ficus cunia* (49.96%) and low in *Vitis parkeri* (10.58%). The other trees had moderate dry matter content. The dry matter content was significantly different among different groups (P<0.01) (Table 4.17).

If we compare each group with the other, there was non significant difference between G1 and G2, G3 and G4 but significant difference between G1and G3, G1and G4, G2 and G3, G2 and G4 (P<0.01) (Table 4.18, 4.19, 4.20, 4.21, 4.22, 4.23).

4.16.2 Crude protein (CP)

The range of CP in different feeds was from 5.05% (hay of *Themeda anathera*) to 25.02% (*Grewia optiva*) in different groups (Table 4.16). Among the tree leaves, the CP content was highest in *Grewia optiva* (25.02%) and lowest in *Quercus leucotrichophora* (10.77%). The CP content amongst grasses varied from 5.05% (the hay of *Themeda anathera* grass) to 7.40% (mixed green grass). In crop residues, CP content was 3.23% (paddy straw) and 3.60% (maduwa straw) and in experimental feeds CP content was highest in UMMB (22.14%) and lowest in *Chaata* (16.19%) (Table 4.16). Average CP content was 16.64±1.03% in tree leaves, 6.32±0.43% in grasses, and 3.14±0.185% in crop residues and 18.32±1.91% in experimental feeds (Table 4.17). Among the groups, CP content was significantly different (P<0.01). There was significant difference between group G1 and G2, G1 and G3, G2 and G4, G3 and G4 (P<0.01) but the difference was not significant between G1 and G4, G2 and G3 (Table 4.18, 4.19, 4.20, and 4.21, 4.22, 4.23).

4.16.3 Ether extracts (EE)

The EE content was highest in *Chaata* (6.03%) and lowest in *Beru* (*Ficus palmata*) (1.08%) (Table 4.16). In different tree leaves, the EE range was between 1.08% (*Ficus palmata*) to 3.00% (*Grewia optiva*). Among the grasses, the EE range was from 1.67% (*Themeda anthera* green) to 2.91% (mixed green grass). EE content was higher in maduwa straw (1.56%) as compared to paddy straw (1.45%) in crop residues (Table 4.16). Among the experimental feeds, highest EE content was in *Chaata* (6.03%) and lowest in UMMB (1.14%). There was no significant difference between different feed samples in EE content in different groups.

4.16.4 Crude fibre (CF)

The results presented in Table 4.17 reveal that the CF content was significantly different among the groups (P<0.01). CF range varied from 4.84% (UMMB) to 48.89% (maduwa straw) in different groups (Table 4.16). In tree leaves the CF content varied from 9.89% (*Pyrunus cerariades*) to 23.04% (*Machilus duthiei*), In grasses, CF content ranged from 26.41% (mixed green grass) to 34.15% (*Themeda anathera*). In crop residues, the CF content varied from 45.60% (paddy straw) to 48.89% (maduwa straw) and in experimental feeds the CF content varied from 4.87% (UMMB) to 21.69% (CFB). CF content was significantly different between G1 and G2, G1 and G3, G2 and G3, G2 and G4, G3 and G4 (P<0.01), G1 and G4 (P<0.05), (Table 4.18, 4.19, 4.20, 4.21, 4.22, 4.23).

4.16.5 Total ash (TA)

TA content was not significantly different among the groups. The range of ash content in different groups was from 2.89% (*Chaata*) to 20.44% (UMMB). Among the tree leaves, the highest ash content was in *Ficus roxburghii* (17.33%). It was the lowest in *Chaata* (2.89%). In grasses, ash content varied between 6.06% (*Themeda anathera* green) to 12.52% (mixed green grass), in crop residues, the ash content was 10.27% (maduwa straw) and 10.27% (paddy straw) and in experimental feeds the ash content varied between 2.89% (*Chaata*) to 20.44% (UMMB).

4.16.6 Acid insoluble ash (AIA)

AIA content was not significantly different between the groups (Table 4.17). Among the tree leaves, the highest AIA content was in *Pyrunus cerariades* (6.51%) and lowest in *Machilus duthiei* (0.33%). In grasses, the AIA content was highest in mixed green grass (6.06%) and lowest in 2.35% (*Themeda anathera* green). In crop residues, the AIA content was 4.60% (maduwa straw) and 6.06% (paddy straw) and in experimental feeds the AIA content was 0.93% in *Chaata* and 7.43 % in UMMB (Table 4.16).

4.16.7 Neutral detergent fibre (NDF)

The average NDF content of various tree species, grasses, crop residues and experimental feeds was 54.03±0.86, 55.83±1.317, 68.57±1.55, 31.11±13.50% respectively and all were significantly different with each other ($P<0.01$) (Table 4.17). The NDF content varied from 46.76% (*Grewia optiva*) to 59.70% (*Machilus duthiei*) in tree leaves, from 52.64% (mixed green grass) to 59.64% (*Themeda anthera* green) in grasses, from 67.02% (maduwa straw) to 70.12% (paddy straw) and from 14.60% (*Chaata*) to 57.87% (CFB) in experimental feeds. There was significant difference between G1 and G3 ($P<0.05$), G1 and G4, G2 and G4, G3 and G4 ($P<0.01$) but not significant difference between G1 and G2, G2 and G3 (Table 4.18, 4.19, 4.20, 4.21, 4.22, 4.23).

4.16.8 Acid detergent fibre (ADF)

ADF ranged from 27.78% (*Grewia optiva*) to 43.45% (*Bauhinia vahlii*) in tree leaves, 34.21% (*Themeda anathera* green) to 46.82% (mixed green grass) in grasses, 42.85% (paddy straw) to 44.07% (maduwa straw) in crop residues and 9.10 % (*Chaata*) to 34.48% (CFB) in experimental feeds (Table 4.16). ADF content was significantly different between the groups (P<0.01) (Table 4.17).

4.16.9 Nitrogen free extracts (NFE)

There was non-significant difference amongst the groups in NFE content (Table 4.17). The range of NFE content was from 35.68% (maduwa straw) to 69.72% (*Chaata*) (Table 4.16). The average NFE content was 51.15±1.96, 52.94±0.77, 37.50±1.84 and 53.98±8.50% in tree leaves, grasses, crop residues and experimental feeds respectively (Table 4.17). There was significant difference between G1 and G3, G2 and G3, G3 and G4 (P<0.05) (Table 4.19, 4.21, 4.23).

4.16.10 Organic matter (OM)

The average OM content was 87.20±1.21% in tree leaves, 90.70±1.19% in grasses, 89.69±3.62% in crop residues and 85.85±5.63% in experimental feeds (Table 4.17). There was no significant difference in OM content in different groups (Table 4.17). Highest OM content was 97.11% (*Chaata*) and lowest 80.90% (CFB) among the groups (Table 4.16).

Table 4.16: Chemical composition (%) and nylon bag dry matter digestibility (NBDMD, %) of different feeds on dry-matter basis

Samples	DM	CP	EE	CF	TA	AIA	NDF	ADF	NFE	OM	Hemicelluloses	NBDMD
Tree leaves												
Bhimal (*Grewia opiva)*	42.60	25.05	3.00	16.70	17.51	4.12	46.76	27.78	37.74	82.49	18.98	67.00
Kharik (*Celtis australis)*	33.70	20.39	2.15	15.92	12.57	3.37	55.69	34.95	48.97	87.43	20.74	66.00
Rampauren* *(Vitis parkeri)*	10.58	19.16	2.70	20.17	17.11	1.42	53.25	41.67	40.86	82.89	11.58	63.00
Saujan *(Ougenia delbaegioides)*	30.65	15.80	1.44	18.58	16.26	0.50	56.52	42.53	47.92	83.74	13.99	40.00
Betula *(Ficus clavata)*	40.51	13.37	1.15	17.81	13.63	3.25	54.68	38.15	54.04	86.37	16.53	65.00
Timal *(Ficus roxburghii)*	32.50	15.13	2.70	18.74	17.33	5.85	52.13	36.87	46.10	82.67	15.26	61.00
Beru *(Ficus palmata)*	25.65	17.07	1.08	11.10	12.29	1.74	54.68	30.58	58.46	87.71	24.10	48.00
Kaul *(Machilus duthiei)*	38.53	15.49	1.14	23.04	7.08	0.33	59.70	41.06	53.25	92.92	18.64	49.00
Oak *(Quercus leucotricophora)*	49.45	10.77	3.81	19.54	4.28	0.56	50.84	42.89	61.60	95.72	7.95	49.00
Doodla *(Ficus nemoralis)*	34.68	16.53	1.09	17.43	9.15	1.66	53.76	40.23	55.80	90.85	13.53	52.00
Khinyo*(Ficus cunia)*	49.96	12.14	1.78	19.12	8.10	0.88	54.67	39.08	58.86	91.90	15.59	55.00
Kwaral *(Bauhinia vahlii)*	42.70	16.34	1.21	20.53	15.15	5.88	56.70	43.45	46.77	84.85	13.25	62.00
Phanya *(Pyrunus cerariades)*	37.49	19.15	1.40	9.89	15.87	6.51	53.08	29.02	53.69	84.13	24.06	55.00
Grasses												
Themeda anathera green	19.89	5.62	2.33	34.15	6.06	2.35	59.64	34.21	51.84	93.94	25.43	55.00
Mixed green grass	21.97	6.50	1.67	28.09	10.66	5.31	58.20	46.53	53.08	89.34	11.67	48.00
Mixed green grass	25.89	7.05	2.09	26.89	10.17	6.06	52.64	35.29	53.80	89.83	17.35	43.00
Mixed green grass	27.78	7.40	2.91	26.41	12.52	5.20	54.29	37.05	50.76	87.48	17.24	51.00
Themeda anathera hay	85.71	5.05	1.69	30.97	7.05	4.70	54.40	46.82	55.24	92.95	17.47	40.00
Crop residues												
Paddy straw	89.90	3.23	1.45	45.60	10.35	6.06	70.12	42.85	39.37	89.65	27.27	52.00
Maduwa straw	88.70	3.60	1.56	48.89	10.27	4.60	67.02	44.07	35.68	89.73	22.95	52.00
Experimental feeds												
UMMB	81.20	22.14	0.87	4.87	20.44	7.43	20.87	12.44	51.68	79.56	8.43	85.00
CFB (Complete feed block)	86.50	16.64	2.01	21.69	19.10	7.03	57.87	34.48	40.56	80.90	23.39	68.00
Chaata	93.70	16.19	6.03	5.17	2.89	0.93	14.60	9.10	69.72	97.11	5.5	90.00

*succulent

Table 4.17: Nutritive values (percent) comparison between different tree leaves, fodders and feeds

Parameters	Tree leaves	Grasses	Crop residues	Experimental feeds
Dry matter**	36.07 ± 2.880	36.24 ± 12.443	89.30 ± 0.599	87.13 ± 3.622
Crude protein**	16.64 ± 1.034	6.32 ± 0.437	3.14 ± 0.185	18.32 ± 1.912
Ether extract	1.89 ± 0.248	2.13 ± 0.229	1.50 ± 0.549	3.06 ± 1.506
Crude fibre**	17.58 ± 1.008	29.30 ± 1.448	47.24 ± 0.164	10.57 ± 5.557
Total ash	12.79 ± 1.214	9.29 ± 1.194	10.31 ± 0.039	14.14 ± 5.639
Acid insoluble ash	2.74 ± 0.616	4.72 ± 0.632	5.330 ± 0.730	5.13 ± 2.103
Neutral detergent fibre**	54.03 ± 0.868	55.83 ± 1.317	68.57 ± 1.550	31.11± 13.500
Acid detergent fibre**	37.55 ± 1.500	39.98 ± 2.770	43.46 ± 0.609	18.67 ± 7.961
Digestibility**	56.76 ± 2.353	47.40 ± 2.694	52.00 ± 0.000	81.00 ± 6.658
Nitrogen free extract	51.15 ± 1.96	52.94 ± 0.774	37.25 ±1.844	53.98 ± 8.509
Organic matter	87.20 ± 1.21	90.70 ± 1.194	89.69 ± 3.624	85.85 ± 5.639
Hemicelluloses	16.47 ± 1.31	15.85 ± 3.015	25.11 ± 2.160	12.44 ± 5.539

** Significant difference $P<0.01$

Table 4.18: Comparison of nutritive values (percent) between tree leaves and grasses

Parameters	*Tree leaves*	*Grasses*	*cd 5%*	*cd 1%*
Dry matter	$36.07^{a} \pm 2.880$	$36.24^{a} \pm 12.443$	16.89	23.09
Crude protein	$16.64^{b} \pm 1.034$	$6.32^{a} \pm 0.437$	3.50*	4.79**
Ether extract	$1.89^{a} \pm 0.248$	$2.13^{a} \pm 0.229$	1.24	1.70
Crude fibre	$17.58^{a} \pm 1.008$	$29.30^{b} \pm 1.448$	4.99*	6.83**
Total ash	$12.79^{a} \pm 1.214$	$9.29^{a} \pm 1.194$	5.35	7.32
Acid insoluble ash	$2.74^{a} \pm 0.616$	$4.72^{a} \pm 0.632$	2.46	3.36
Neutral detergent fibre	$54.03^{a} \pm 0.868$	$55.83^{a} \pm 1.317$	8.93	12.21
Acid detergent fibre	$37.55^{a} \pm 1.500$	$39.98^{a} \pm 2.770$	7.52	10.27
Digestibility	$56.76^{b} \pm 2.353$	$47.40^{a} \pm 2.694$	9.02*	12.33
Nitrogen free extract	$51.15^{a} \pm 1.96$	$52.94^{a} \pm 0.774$	8.20	11.21
Organic matter	$87.20^{a} \pm 1.21$	$90.70^{a} \pm 1.194$	5.35	7.32
Hemicelluloses	$16.47^{a} \pm 1.31$	$15.85^{a} \pm 3.015$	6.41	8.76

Values bearing different superscripts in a row differ significantly; $^{*}P<0.05$, $^{**}P<0.01$

Table 4.19: Comparison of nutritive values (percent) between tree leaves and crop residues

Parameters	Tree leaves	Crop residues	cd 5%	cd 1%
Dry matter	$36.07^{a} \pm 2.880$	$89.30^{b} \pm 0.599$	24.38*	33.33**
Crude protein	$16.64^{b} \pm 1.034$	$3.14^{a} \pm 0.185$	5.06*	6.92**
Ether extract	$1.89^{a} \pm 0.248$	$1.50^{a} \pm 0.549$	1.79	1.70
Crude fibre	$17.58^{a} \pm 1.008$	$47.24^{b} \pm 0.164$	7.21*	9.85**
Total ash	$12.79^{a} \pm 1.214$	$10.31^{a} \pm 0.039$	7.73	10.56
Acid insoluble ash	$2.74^{a} \pm 0.616$	$5.330^{a} \pm 0.730$	3.55	4.85
Neutral detergent fibre	$54.03^{a} \pm 0.868$	$68.57^{b} \pm 1.550$	12.89*	17.62
Acid detergent fibre	$37.55^{a} \pm 1.500$	$43.46^{a} \pm 0.609$	10.85	14.83
Digestibility	$56.76^{a} \pm 2.353$	$52.00^{a} \pm 0.000$	13.02	17.80
Nitrogen free extract	$51.15^{b} \pm 1.96$	$37.25^{a} \pm 1.844$	11.84*	16.18
Organic matter	$87.20^{a} \pm 1.21$	$89.69^{a} \pm 3.624$	7.73	10.56
Hemicelluloses	$16.47^{a} \pm 1.31$	$25.11^{b} \pm 2.160$	9.25	12.65

Values bearing different superscripts in a row differ significantly; $^{*}P<0.05$, $^{**}P<0.01$

Table 4.20: Comparison of nutritive values (percent) between tree leaves and experimental feeds

Parameters	Tree leaves	Experimental feeds	cd 5%	cd 1%
Dry matter	$36.07^{a} \pm 2.880$	$87.13^{b} \pm 3.622$	20.56*	28.10**
Crude protein	$16.64^{a} \pm 1.034$	$18.32^{a} \pm 1.912$	4.27	5.83
Ether extract	$1.89^{a} \pm 0.248$	$3.06^{a} \pm 1.506$	1.51	2.07
Crude fibre	$17.58^{b} \pm 1.008$	$10.57^{a} \pm 5.557$	6.08*	8.31
Total ash	$12.79^{a} \pm 1.214$	$14.14^{a} \pm 5.639$	6.51	8.91
Acid insoluble ash	$2.74^{a} \pm 0.616$	$5.13^{a} \pm 2.103$	2.99	4.09
Neutral detergent fibre	$54.03^{b} \pm 0.868$	$31.11^{a} \pm 13.500$	10.87*	14.86**
Acid detergent fibre	$37.55^{b} \pm 1.500$	$18.67^{a} \pm 7.961$	9.15*	12.51**
Digestibility	$56.76^{a} \pm 2.353$	$81.00^{b} \pm 6.658$	10.98*	15.01**
Nitrogen free extract	$51.15^{a} \pm 1.96$	$53.98^{a} \pm 8.509$	9.98	13.64
Organic matter	$87.20^{a} \pm 1.21$	$85.85^{a} \pm 5.639$	6.51	8.91
Hemicellulose	$16.47^{a} \pm 1.31$	$12.44^{a} \pm 5.539$	7.80	10.66

Values bearing different superscripts in a row differ significantly; *P<0.05, **P<0.01

Table 4.21: Comparison of nutritive values (percent) between grasses and crop residues

Parameters	Grasses	Crop residues	cd 5%	cd 1%
Dry matter	$36.24^{a} \pm 12.443$	$89.30^{b} \pm 0.599$	26.86*	36.71**
Crude protein	$6.32^{a} \pm 0.437$	$3.14^{a} \pm 0.185$	5.57	7.62
Ether extract	$2.13^{a} \pm 0.229$	$1.50^{a} \pm 0.549$	1.98	2.70
Crude fibre	$29.30^{a} \pm 1.448$	$47.24^{b} \pm 0.164$	7.94*	10.85**
Total ash	$9.29^{a} \pm 1.194$	$10.31^{a} \pm 0.039$	8.51	11.63
Acid insoluble ash	$4.72^{a} \pm 0.632$	$5.330^{a} \pm 0.730$	3.91	5.34
Neutral detergent fibre	$55.83^{a} \pm 1.317$	$68.57^{a} \pm 1.550$	14.20	19.41
Acid detergent fibre	$39.98^{a} \pm 2.770$	$43.46^{a} \pm 0.609$	11.95	16.34
Digestibility	$47.40^{a} \pm 2.694$	$52.00^{a} \pm 0.000$	14.34	19.61
Nitrogen free extract	$52.94^{b} \pm 0.774$	$37.25^{a} \pm 1.844$	13.04*	17.82
Organic matter	$90.70^{a} \pm 1.194$	$89.69^{a} \pm 3.624$	8.51	11.63
Hemicellulose	$15.85^{a} \pm 3.015$	$25.11^{a} \pm 2.160$	10.19	13.93

Values bearing different superscripts in a row differ significantly; *$P<0.05$, **$P<0.01$

Table 4.22: Comparison of nutritive value (percent) between grasses and experimental feeds

Parameters	Grasses	Experimental feeds	cd 5%	cd 1%
Dry matter	$36.24^{a} \pm 12.443$	$87.13^{b} \pm 3.622$	23.44*	32.04**
Crude protein	$6.32^{a} \pm 0.437$	$18.32^{b} \pm 1.912$	4.86*	6.65**
Ether extract	$2.13^{a} \pm 0.229$	$3.06^{a} \pm 1.506$	1.72	2.36
Crude fibre	$29.30^{b} \pm 1.448$	$10.57^{a} \pm 5.557$	6.93*	9.47**
Total ash	$9.29^{a} \pm 1.194$	$14.14^{a} \pm 5.639$	7.43	10.15
Acid insoluble ash	$4.72^{a} \pm 0.632$	$5.13^{a} \pm 2.103$	3.41	4.66
Neutral detergent fibre	$55.83^{b} \pm 1.317$	$31.11^{a} \pm 13.500$	12.40*	16.95**
Acid detergent fibre	$39.98^{b} \pm 2.770$	$18.67^{a} \pm 7.961$	10.43*	14.26**
Digestibility	$47.40^{a} \pm 2.694$	$81.00^{b} \pm 6.658$	12.52*	17.11**
Nitrogen free extract	$52.94^{a} \pm 0.774$	$53.98^{a} \pm 8.509$	11.38	15.55
Organic matter	$90.70^{a} \pm 1.194$	$85.85^{a} \pm 5.639$	7.43	10.15
Hemicellulose	$15.85^{a} \pm 3.015$	$12.44^{a} \pm 5.539$	8.90	12.16

Values bearing different superscripts in a row differ significantly; *$P<0.05$, **$P<0.01$

Table 4.23: Comparison of nutritive values (percent) between crop residues and experimental feeds

Parameters	Crop residues	Experimental feeds	cd 5%	cd 1%
Dry matter	$89.30^{a} \pm 0.599$	$87.13^{a} \pm 3.622$	29.30	40.05
Crude protein	$3.14^{a} \pm 0.185$	$18.32^{b} \pm 1.912$	6.08*	8.31**
Ether extract	$1.50^{a} \pm 0.549$	$3.06^{a} \pm 1.506$	2.16	2.95
Crude fibre	$47.24^{b} \pm 0.164$	$10.57^{a} \pm 5.557$	8.66*	11.84**
Total ash	$10.31^{a} \pm 0.039$	$14.14^{a} \pm 5.639$	9.29	12.69
Acid insoluble ash	$5.330^{a} \pm 0.730$	$5.13^{a} \pm 2.103$	4.26	5.83
Neutral detergent fibre	$68.57^{b} \pm 1.550$	$31.11^{a} \pm 13.500$	15.50*	21.18**
Acid detergent fibre	$43.46^{b} \pm 0.609$	$18.67^{a} \pm 7.961$	13.04*	17.83**
Digestibility	$52.00^{a} \pm 0.000$	$81.00^{b} \pm 6.658$	15.65*	21.39**
Nitrogen free extract	$37.25^{a} \pm 1.844$	$53.98^{b} \pm 8.509$	14.23*	19.44
Organic matter	$89.69^{a} \pm 3.624$	$85.85^{a} \pm 5.639$	9.29	12.69
Hemicelluloses	$25.11^{b} \pm 2.160$	$12.44^{a} \pm 5.539$	11.12*	15.20

Values bearing different superscripts in a row differ significantly; $^{*}P<0.05$, $^{**}P<0.01$

4.16.11 Hemicelluloses

There was non significant difference between the groups in hemicelluloses content (Table 4.17). Highest hemicelluloses content was 25.43% in *Themeda anathera* green and lowest 5.5% in *Chaata* (Table 4.16). The average hemicelluloses content was 16.47±1.31, 15.85±3.01, 25.11±2.16 and 12.44±5.53% in tree leaves, grasses, crop residues and experimental feeds (Table 4.17). There was significant difference between G1 and G3, G3 and G4 ($P<0.05$) (Table 4.19, 4.23).

4.16.12 Nylon bag dry matter digestibility (NBDMD)

Nylon bag dry matter digestibility (NBDMD) was significantly different among the groups ($P<0.01$) (Table 4.17). The digestibility values ranged from 40.00% (hay of *Themeda anathera*) to 90.00% (*Chaata*) (Table 4.16). The average digestibility was 56.76±2.35% in tree leaves, 47.40±2.69% in grasses, 52.00±0.00% in crop residues and 81.00± 6.65% in experimental feeds (Table 4.17). Digestibility was highest (67.00%) in *Grewia optiva* and lowest (40.00%) in *Ougenia delbaegioides* in tree leaves. In grasses, it was the highest (55.00%) in *Themeda anathera* green and the lowest (40.00%) in the hay of *Themeda anathera.* In crop residues, it was the highest and the lowest in maduwa straw and paddy straw, respectively. In the experimental feeds, the highest value (90.00%) was recorded in *Chaata* and the lowest (68.00%) in CFB (Table 4.16). Digestibility was significantly different in G1 and G2 ($P<0.05$), G1 and G4, G2 and G4, G3 and G4 ($P<0.01$) but not between G2 and G3, G1 and G3 (Table 4.18, 4.20, 4.22, 4.23, 4.21, 4.19)

Many a workers (Singh 1985; Singh and Naik 1987; Singh *et al.* 1988, 1990, 1992; Debnath and Singh 1990; Singh *et al.* 1995; Bohra 2003; Yadav 2003) have already attempted to determine nutritive and digestibility values of uncultivated forest-and agroforestry- based fodders. While in most of the cases our values are in conformity with theirs, we have included some more fodder species in our analyses and the values presented in this analysis perhaps for the first time give some more important clues about the potentials of rangelands serving as the appropriate habitats for fodder species.

4.17 Traditional management of rangeland resources

Animal husbandry is older than crop cultivation. Human civilization, in fact, entered into a new phase of its development thanks to adoption and practices of animal husbandry. Range management appears to be as old as animal husbandry. And so is the knowledge relating to range management. Range management also appears to be the oldest art of natural resource management. Since the dawn of civilization, natural resource management systems have been the local community-based systems. Indigenous perceptions and practices regarding management of natural resources primarily concerned with protection and utilisation of biologically diverse resources. Natural resource management systems virtually are as diverse as the human-inhabited ecosystems on Earth.

As the world's largest mountain system, the Himalayan region has unique functions and roles and range management by local farmers and transhumant societies is the largest intervention into it. Throughout the history the interaction between mountain people and the natural systems had helped communities to maintain the richness of species, communities and genetic materials in both the productive systems and wild lands of the mountain environments (Shengji 1994).

There have been three fundamental means to manage rangelands in the Himalayan mountains, particularly in its north-western region: i) burning of the forests; ii) cutting down and/ or thinning of the forests; and iii) abandonment of cultivated land.

Amongst them the first has been the method that could be easily handled by people. Slash-and-burn farming, also called the swidden farming, shifting farming or *jhoom* cultivation in the north-eastern hills, is different from that practiced in the north-western Himalayan mountains. While in the former case the cleared forest area is used for cultivating food and/ or cash crops and place of agricultural activities is changed after a cycle of few years is completed, in the latter, the forest area is managed for pastoral activities and it is a part of settled agriculture.

Cutting down or thinning of a forest area is an old art of silvi-pasture management. It involves an appropriate mix of woody species and ground flora of herbaceous plants dominated by grasses. Such a management of specific vegetation involving economic species to provide specific products (foods, fodder, fuel wood, fibre, timber, medicines, etc.) and specific functions (soil and water conservation, micro-climate maintenance, synergy, etc.) in the rangeland ecosystems is a wonderful articulation of local farmers' traditional knowledge.

Burning and cutting down and/ or thinning of forests allows the herbaceous species (graminae and non-graminae families) to thrive on ground exposed to more solar radiation. These species are of special socio-economic importance. In a rangeland, the first preference is given to the fodder species. The ground flora is virtually used as fodder for livestock. However, woody species occurring in a rangeland ecosystem, through their leaf biomass, also contribute significant amount of fodder. All woody species are often used for extracting fuel wood while many others may be of multiple economic uses simultaneously providing other useful products such as fruits, edible seeds, dyes, medicine, fibre, bedding material, minor timber, agricultural implements, and tools, etc.). Some species may be of little direct economic importance but are maintained to render useful ecosystem services vital for the maintenance of agricultural and livelihood systems in mountain areas.

Abandoned agriculture on a piece of land also results in the development of a rangeland ecosystem. This land is often predominated by grasses and other herbaceous plants interspersed with shrubs and trees, which were originally kept as part of agro-forestry system. The trees and shrubs are broadleaved extensively used for top lopping.

There is yet another practice of farmers in which cultivated land is used as grazing ground during certain period of the year. This is the fallow practice.

Terraced fields used for cultivation are left fallow for a crop season in a year. During this season, livestock can graze on the fallow fields. Grasses of field bunds, green plants, or weeds, growing in the absence of ploughing, leftovers of the previous food crop (leaves, stems and often roots) are grazed by the animals. The private cropland left fallow is also used as CPR during the fallow period. Fellow practice leads to increase in grazing area temporarily. This is the practice adopted by farmers for centuries to give periodic rest to their fields for maintaining fertility of the soils. The soil fertility through fallowing practice is managed by i) preventing draining out of nutrients via food crops, ii) allowing microbial degradation of crop residues (mostly roots), iii) in-situ manuring by the grazing animals, and iv) green manuring upon mixing up green plants/ weeds through ploughing at the end of fallow period.

4.17.1 Grazing management

Grazing of livestock on mountain rangelands in the recent years has been regarded as one of the factors responsible for ecological degradation in the fragile ecosystems. Ecologists today often make advocacy for deferred-cum-rotational grazing. The pastoralists in the Himalayan areas, however, have been adopting this practice for decades, probably for centuries. They do not graze their animals on a single patch in a limited area, for they are well aware that frequent defoliation eventually ends up in the cessation of plant regeneration. They keep shifting grazing area and closing the earlier grazed area for giving enough time for plant regeneration, and so on.

4.17.2 Grass harvesting

Vegetative propagation and sprouting of seeds are the two means of plant regeneration in the ecosystems. Regeneration by seed shedding is taken advantage of so that root reserves of energy are not exhausted by frequent cuttings. The grass is harvested after shedding of seed in the months of October-November. This is the natural way of allowing ecological regeneration of rangelands of which the farmers are well acquainted.

4.17.3 Grass distribution

Managed in protected plots in the village rangelands, the grass is distributed to all families on the basis of some egalitarian principles and social sanctions. Harvesting is to be done by the family members, invariably by women, who have to carry the load to home. A family would bring equal numbers of bundles in a day until all the grass is harvested. Sometime all families would be allotted equal number of days for harvest and bring home as much grass as one can during those days. Sometimes this arrangement is done that a woman of a family would bring as many head loads of grass as she can during a day harvest. Sometimes numbers of animals with a family would be the criterion of distribution. Grass distribution pattern thus would depend on the mutual decision of the people of a *gramsabha*. Social sanctions accorded by a *Gramsabha* or informal organization of socially more active members of the village community will have to be abided by all.

4.17.4 Fodder preservation

The harvested grass is preserved to be fed to livestock during winter season. People are well aware of the natural preservation methods, a technology which is centuries old. The grass is spread loose often on rooftops or on the broad fence around homestead and sun-dried for a couple of days. Moisture percentage is kept less than 10 percent. Also recommended by the animal scientists, this moisture level curbs microbial growth in the plants that could take place at appropriate moisture level and thus helps preserve the fodder for longer duration.

Nutritive value of fodder is also taken care of in a scientific manner by the farmers when applying natural preservation technology. Leaves of the plants, which are more nutritive than the stem, are not allowed to shatter. Sun-drying also helps increase vitamin D content in the fodder.

The preserved fodder is stacked on the branches of trees around homestead. The stacking method is also a form of an appreciable art. The stacked fodder, locally called *luta* in Kumaun and *purolda* in Garhwal, is given the form of a temple, with broad base gradually ending into a pyramid form at the tip. This shape, 1.0 to 1.5 m straight height, allows the rain water flow down the preserved material quickly with minimum seepage, thus helping prevent the fodder from getting spoiled by increasing moisture content. In mountain areas there is no enough space that could be spared for storage of fodder. The traditional technique of farmers is an appropriate option.

Table 4.24: Indigenous technology of range management in Uttaranchal Himalayas

Management Relating to:	Indigenous Technological Applications	Logic
Niche Ranges	• Diversity at ecosystem level; • Niche-specific vegetation; • A mix of trees, shrubs and herbaceous plants	• Diversity of ecological niches according to altitude, slope direction, amount of precipitation, micro-climate, etc. is naturally available in the mountains (e.g., Dune ranges, forest grazing lands, mid-altitude ranges, alpine pastures, trans-Himalayan ranges, etc.); • Niche-specific vegetation (e.g., subtropical forages, temperate vegetation, alpine meadows, or sal type, oak type, alpine type, etc.) creates diversity amongst and within species that is used in range management and subsequently in nourishing livestock-dominated local livelihoods; • A mix of vegetation types makes the rangeland ecosystems, more heterogeneous, ecologically more stable, more resilient and more productive.
Floral Composition	• Periodic burning; • Cutting down and/ or thinning of forests	• Allows the herbaceous species (graminae and non-graminae families) to thrive on ground exposed to more solar radiation; • Dominance of the vegetation of greater socio-economic importance; • More amount of fodder flow from the ecosystems for raising livestock; • Maintenance of species

		of intangible uses contributing to vital ecosystem services.
Cultivated Lands	• Abandonment of Agriculture on poor lands; Practice of periodic fallowing.	• Appropriate land use; • More efficient use of cultivated land; • Use of PPRs as CPRs that enhances socio-cultural cohesion within a community; • Improvement in the fertility status of soils of the fallow lands through preventing draining out of nutrients via food crops, allowing microbial degradation of crop residues (mostly roots), in-situ manuring by the grazing animals, and green manuring upon mixing up green plants/ weeds through ploughing at the end of fallow period.
Grazing	• Rotational-cum deferred grazing of livestock; • Fencing; • Enclosure of areas/ plots for harvest of grass at appropriate time for stall-feeding of livestock.	• Avoidance of frequent defoliation and trampling upon of plants for quick regeneration of palatable plants; • Plots left for harvesting grass for feeding during winter season; • More appropriate use of uncultivated lands.
Distribution	• Distribution of grass before harvest to all families on equal basis following social sanctions; • Harvest by individual families.	• Egalitarian distribution indicative of benefit sharing and social justice maintained through social sanctions; • Strengthening of local governance; • Appropriate participatory management of CPRs.
Harvesting	• Annual cutting of grass after seed set and seed shed	• Ecological regeneration of plants through vegetative propagation and germination of seeds shed in the grass plots; • Regeneration by seed shedding is taken

		advantage of so that root reserves of energy are not exhausted by frequent cuttings.
Fodder Preservation	• Sun-drying of grass left loose for appropriate period to reduce moisture level to less than 10 percent; • Stacking of unchopped fodder in temple shape on tree branches or wooden poles around homestead.	• Maintenance of nutritive value by keeping leaves intact; • Preventing fodder from spoilage by microbial growth to help preserve the fodder for longer duration; • Increase of vitamin D content in fodder; • Saving from the rain water flow down the preserved material with minimum seepage.

Indigenous management of rangeland resources and its logic matching with modern perspectives has been summarized in Table . It can be clearly seen that indigenous ways of natural resource management are ecologically sound, economically viable and perfectly match with the modern scientific perspective of resource management.

SUMMARY AND CONCLUSION

Summary and Conclusion

Dairy sector development, acquired largely through local resources defying conventional tools of development, is a proud indicator of rural India's socio-economic development contributed by the most deprived and marginalized masses of rural areas. This smallholder dairy development must be cherished, valued and celebrated, for it has elevated India to the Number One position in milk production in the world. The Uttaranchal State like other mountainous States in India – and in fact, like all the areas in the Hindu Kush Himalayan (HKH) Region – is very rich in its livestock resources. Dairy farming has strong linkages with various components of the environment it operates in.

Land use in an area, or the type of a farming system, has enormous bearing on the performance of dairy farming. In mountain areas, farming systems have substantial area under non-cultivated use. Large chunk of this ecologically crucial area encompasses rangelands. Rangelands are the ecological core areas, not merely the 'support areas' as they are often referred to by some scientists. Their role in and contributions to a farming system, and consequently to a farming community, is of enormous value. Dairy farming in mountain areas should be seen and analysed against the backdrop of what is the largest component of a farming system, i.e., the rangelands. This, in fact, is the basis of the present study.

Rangelands and dairy farming are complementary to each other in an integrated farming system such as in the mountains. In this farming system generally uncultivated fodders are used as a source of livestock feed. Rangelands are not only crucial for livestock production, but also critical for crop production.

There were 81% bovine and only 19% ovine species in the study area. Amongst the whole livestock population, there were 64% cattle and 17% buffaloes, besides 19% goats. Amongst cattle, the highest percentage was of bullocks, followed by cows, female calves and male calves. Adult she buffaloes were 84% with 16% female calves. Higher proportion of cattle in the herd reveals the fact that cattle are of multipurpose role in mountain farming and livelihood systems. On an average, there were 3.51 bovine per household. Out of this, the number of bullocks per family was 1.21, of cows 0.762 and of buffaloes 0.56 per household. There was just 0.35 cattle male calf and 0.5 cattle female calf. Buffalo female calf numbered 0.12 per household, on an average. There was no male buffalo calf in the sample families and villages. There was on an average, 0.42 goat and 0.36 poultry birds per household per village.

Average milk production per village per farm per day was 1.70 litres. Milk production was ranging from 1.12 to 2.05 litres per day per farm in study areas. Out of the total milk produced per farm per day, 0.37 litres per day was marketed by the farmers. On an average, a total of 69.66 litre milk was marketed per day per village.

In the three selected villages, 64 cows and 32 buffaloes in the early stage of their lactation period were selected for the feed supplementation experiments. The experiment on the selected cows and buffaloes went on for five months (from October 2005 to February 2006). The first month was used as adaptation period. The data were recorded for four months. The experimentation period fell in the span of the autumn and winter seasons.

Average milk production of T1 (fed traditional diet), T2 (supplemented with CFB), T3 (supplemented with UMMB), and T4 (supplemented with CFB and UMMB) group animals was 2.25±0.16, 2.69±0.16, 2.80±0.16 and 3.31±0.16 kg respectively in cows and 4.50±0.27, 4.88±0.27, 5.00±0.27 and 6.00±0.27 kg in buffaloes, respectively. There was significant increase in production ($P<0.01$) of T2, T3 and T4 groups in comparison to T1 group both in cows and buffaloes. Percent increase in milk production over T1 was highest in the T4 group both in cows and buffaloes (47.11 and 33.33 percent respectively). T3 group recorded 24.44 and 11.11 percent increase in milk production over T1 in cows and buffaloes respectively, while T2 group witnessed only 19.55 and 8.44 percent increase in milk production over T1 in cows and buffaloes, respectively. The effect of supplemented nutrients, thus, was more in cows kept on grazing than on the buffaloes fed on stall. There was no significant difference in milk production between T1 and T2, T2 and T3 but there was the significant difference between T1 and T3, T1 and T4, T2 and T4 in cows. In case of buffaloes there was the significant difference between T1 and T4, T2 and T4, T3 and T4 but not significant difference between T1 and T2, T1 and

T3, T2 and T3. The supplementation of both UMMB and CFB in milking cows and buffaloes ration had contributed to significant increase in milk yields of both the species of dairy animals.

The net income from the CFB and UMMB supplementation in cows and buffaloes during the trial period was computed as difference of total income from extra milk and cost of CFB/ UMMB. The daily net income per cow was estimated at Rs. -0.96, Rs. 4.67 and Rs. 4.55 in T2, T3 and T4 groups respectively. It means that the group fed CFB did record a marginal loss of income. It was due to the fact that the cost of CFB could not be compensated by proportional increase in milk production. Income through buffalo milk was Rs. -6.20 in T2, Rs. 3.15 in T3 and Rs. 6.75 in T4 groups. The average net income per day was higher in T4 (UMMB+CFB) and lower in T2 (CFB). Considerable loss in net income was recorded when the buffaloes were fed on supplemented CFB. Cost of CFB could not compensate due to increased milk production. Hence the loss was recorded.

Rangelands are the uncultivated areas or abandoned cultivated areas and occasionally fallow lands that harbour natural or seeded/ planted vegetation of herbaceous and woody species and that serve as habitats of a variety of wild animals, support domesticated animals, provide unique products and ecosystem services especially vital for the livelihoods of livestock-dependent communities.

Ecosystem services rendered by an ecologically sound ecosystem are more intense and more useful. These services emanating from well-managed rangelands help maintaining an environment congenial for the productive services of a cropland. Conservation of myriad life forms in their own boundaries, moisture circulation in the whole farming system, and maintenance of appropriate micro-climate are the other intangible attributes of the rangeland ecosystems in the mountain agro-ecosystems. The intangible ecosystem services are often not taken into consideration but are very vital for the efficient functioning and performance of the whole agro-ecosystem on which livelihood systems of rural communities are dependent.

Amongst the dry fodders, wheat straw makes the largest contribution (30%). Grass hay and barnyard millet straw also contribute to the major bulk of fodder (18% each) followed by finger millet straw (16%), rice straw (14%) and barley and pulse straw (2% each) over a period of one year. Amongst the green grasses, major bulk (55%) is composed of the green grasses grazed by animals. Hand-cut green grass contributes as much as 30% of the total green supply, while tree leaves and other greens (such as field weeds, mustard, etc.) make 12 and 3% respectively over a period of one year.

More than 150 species of grasses, other herbaceous plants, trees and shrubs were identified in the mid-altitude rangelands in the mountains of Uttaranchal. This variety of fodder species available in the rangelands is really amazing.

Themeda anathera, a grass species, had the highest density of 72.5 per m^2, while *Acacia mimosoides* recorded the least density of 0.5 per m^2. The average herbage productivity values in different rangelands – viz., oak type, mixed type, oak-grass type, oak-conifer type and grass type – were 121.64±12.92g/ m^2, 78.09±16.19g/ m^2, 153.64±23.89g/ m^2, 128.88±20.66g/ m^2 and 106.00±10.52g/ m^2 respectively in summer season. In rainy season productivity was more in comparison to the summer season, which was recorded to be 501.28±66.65g/m^2, 763.20±12.88 g/ m^2, 454.68±27.05 g/ m^2, 692.12±81.48 g/ m^2 and 766.88±23.07g/ m^2 in oak type, mixed type, oak-grass type, oak-conifer type and grass type rangelands respectively. Highest productivity was recorded in oak-grass type rangeland in summer season and grass type in rainy season. Herbage productivity was low in summer season and high in rainy season; it was due to the operating environmental factors which were unfavourable for plant growth during summer season.

Chemical composition and nylon bag dry matter digestibility values of some of the fodder species collected during study showed a wide variation in both within and amongst the types (tree leaves, grasses, crop residues and experimental feeds).

Range management appears to be as old as animal husbandry. And so is the knowledge relating to range management. Range management also appears to be the oldest art of natural resource management. Since the dawn of civilization, natural resource management systems have been the local community-based systems. Indigenous perceptions and practices regarding management of natural resources primarily concerned with protection and utilisation of biologically diverse resources. Natural resource management systems virtually are as diverse as the human-inhabited ecosystems on Earth.

As the world's largest mountain system, the Himalayan region has unique functions and roles and range management by local farmers and transhumant societies is the largest intervention into it. Development of silvi-pastoral systems conducive to regional geo-ecological specificities and grazing management, grass harvest, fodder distribution, fodder preservation and fodder stacking are some of the ways in which traditional management practices using local community-based knowledge are pivotal. Traditional rangeland management in mountain areas should be properly understood, recognized and promoted for evolving ecologically sound, economically viable and socially just strategies of development in the fragile mountains. Reconciliation of rangeland management and dairy farming would help acquire a new dimension and renewed impetus to the most desirable community-based development in mountain areas.

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Abstract

In the integrated farming systems in the mountains, dairy farming depends on rangeland resources. The present study was framed from this point of view. The average livestock composition in a cluster of four villages in the Almora district of Uttaranchal included 81% bovine and 19% ovine. Amongst the whole livestock population, there were 64% cattle, 17% buffaloes and 19% goats.

In the three selected villages, 64 cows and 32 buffaloes in the early stage of their lactation period were selected for the feed supplementation experiments for five months (October 2005 to February 2006) including one month for adaptation period. Average milk production of T1 (fed traditional diet), T2 (supplemented with complete feed block, CFB), T3 (supplemented with urea-molasses-mineral block, UMMB), and T4 (supplemented with CFB and UMMB) group of animals was 2.25±0.16, 2.69±0.16, 2.80±0.16 and 3.31±0.16 kg respectively in cows and 4.50±0.27, 4.88±0.27, 5.00±0.27 and 6.00±0.27 kg in buffaloes, respectively. There was significant increase in milk production ($P<0.01$) of T2, T3 and T4 groups in comparison to T1 group both in cows and buffaloes. There was no significant difference in milk production between T1 and T2, T2 and T3 but there was significant difference between T1 and T3, T1 and T4, T2 and T4 in cows. In case of buffaloes there was significant difference between T1 and T4, T2 and T4, T3 and T4 but no significant difference between T1 and T2, T1 and T3, T2 and T3. The daily net income per cow was estimated at Rs. -0.96, Rs. 4.67 and Rs. 4.55 in T2, T3 and T4 groups respectively. Chemical composition and nylon bag dry matter digestibility values of feed and fodder samples showed a wide variation.

More than 150 species of grasses, other herbaceous plants, trees and shrubs of vital fodder values were identified in the mid-altitude rangelands in the mountains of Uttaranchal. This variety of fodder species available in the rangelands is really amazing. *Themeda anathera*, a grass species, had the highest density of 72.5 per m^2, while *Acacia mimosoides* recorded the least density of 0.5 per m^2. The average herbage productivity values in different rangelands – viz., oak type, mixed type, oak-grass type, oak-conifer type and grass type – were 121.64±12.92, 78.09±16.19, 153.64±23.89, 128.88±20.66 and 106.00±10.52 g per m^2 respectively in summer season. In rainy season productivity was more in comparison to the summer season, which was recorded to be 501.28±66.65, 763.20±12.88, 454.68±27.05, 692.12±81.48 and 766.88±23.07 g per m^2 in oak type, mixed type, oak-grass type, oak-conifer type and grass type rangelands respectively. Highest productivity was recorded in oak-grass type rangeland in summer season and grass type in rainy season. Herbage productivity was low in summer season and high in rainy season. Range management, in essence, is the key to sustainable dairy farming in mountain areas.

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