

Fodder production system-a major challenge in cold arid region of Ladakh, India

Abstract

The Himalayan mountain range has significant bearing on the climate of India, as its towering height created a vast rain shadow zone in the north. Among the cold arid parts of India, Ladakh in Jammu & Kashmir is one of the highest (2900m to 5900m asl) and coldest. Leh and Kargil are two districts, which jointly form Ladakh region, the principal cold desert of India. Leh with an area of 45,110 sq km is the largest district in the country located in an altitudinal range from 2900 to 5900 m above mean sea level. Being cold arid region, the temperature ranges between -35°C in winter to +35°C in summer. In general, area has short mild summer to long cold winter. Agriculture and animal husbandry in cold arid region are interwoven with the intricate fabric of the society in cultural, religious and economical ways. It is beyond any doubt that livestock production is the major production system of Ladakh region of the Indian Trans-Himalaya. Because of dissected topography with snow clad high mountains and absolutely inhospitable environmental conditions, areas available for cultivation and other utilizable land uses are not much. Majority of farmers follow mixed farming however, 'Changpas' who inhabit Changthang area of Leh district follows a nomadic life; always moving in search of greener pastures to ensure continuity to their livelihood source in one of the environmentally harshest areas of the country. The grassland vegetation in the Indian Himalaya occupies nearly 35% of the geographical area and five grassland types are defined. In animal feed supply, cereals and other cash crops have a major role. Fodder availability in cold arid regions is 40-50 per cent of the actual requirement however, in some areas it is more than 50%. Alfalfa and crop residue are major parts of fodder base in cold arid region of India. A case study of village Nang indicated a deficit of fodder to the tune of 73% at village level. Huge deficit of fodder at village level itself explain great significance of high altitude pasture lands.

In general, average deficiency of 40-45% fodder is the major constraint for livestock production systems of cold arid regions of Ladakh. In fact, shortage of alfalfa and receding area of cereal crops are the main bottleneck for livestock production because ample amount of fodder in form of straw is available from cereal crops however, in case of alfalfa seeds of the species, being imported face difficulty in adaptation due to severe winter and other factors. In terms of energy output, the higher values were also obtained for cereal crops' fodder. Though energy output values for fodder was maximum for alfalfa, a unique fodder species for the region but it required very high amount of inputs in comparison to cereal crops. Even then the importance of alfalfa as a fodder crop will be there for sustaining the availability of fodder. Understanding of the environment and a vast body of traditional knowledge systems have enabled mountain people to plan and implement activities, such as traditional land and livestock management practices that are still fundamental for low-intensity production systems at high altitudes. Therefore, the immediate focus is required for re-generation of pasture lands and increase in alfalfa production areas.

Keywords: changthang, alfalfa, pashmina, tsampa, pronges pabularis, carex, caragana pygme, ICAR-CAZRI, agropyron, agrostis, alopecurus, bromus, cicer, lespedeza, Artemisia, oryzopris, lolium, medicago, melilotus, trifolium

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Tewari JC,¹ Pareek K,¹ Raghuvanshi MS,¹ Praveen Kumar,¹ Roy MM²¹Central Arid Zone Research Institute, India²Indian Sugarcane Research Institute, India

Correspondence: Valentine Pankowski, Department of Chalcolithic and the Bronze Age Archaeology, The National Academy of Sciences of Ukraine, Ukraine, Tel (044) 418-9195, Fax (044) 418-3306, Email vpns@ukr.net

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Introduction

The Himalaya occupies only seven per cent area of India and the twelve Himalayan states have a huge livestock population. This huge livestock population is multiplying at a high rate and due to ever increasing grazing pressure on grazing lands, pastures and scrub lands, they are degrading with a faster pace resulting in acute fodder shortage. However, agriculture and animal husbandry in cold arid region are interwoven with the intricate fabric of the society in cultural, religious and economical ways as mixed farming and

livestock rearing form an integral part of rural living. Rangelands, limited crop lands and livestock are vital to the economy and culture of cold arid zone of India. Despite their importance, rangelands and their products receive little attention in agricultural policies in much of the Hindu Kush Himalayan region. Of primary importance is the value of livestock in the local subsistence and market economy. This is reflected in the fact that the majority of Ladakh's landscapes are more suitable for livestock husbandry rather than crop cultivation. For centuries, these rangelands have produced the finest pashmina

wool in the world.¹ Sheep wool has also been traded externally for use in clothing and for stuffing pillows and bedding. In addition to goat and sheep wool, these rangelands also provide other key livestock products and services such as meat, dairy, labor and organic fertilizer. Thus, without any doubt livestock production is the major production system of Ladakh region of the Indian Trans Himalaya. Therefore fodder production, supply and conservation for lean period is a vital issue for livestock production systems of Ladakh, which forms principal cold arid region of the country.

Land use pattern in Ladakh

The total geographic area of the region district (Leh and Kargil) is 96701sq. kilometers. Because of dissected topography with snow

clad high mountains and absolutely inhospitable environmental conditions, areas available for cultivation and other utilizable land uses are not much. The land utilization pattern of reporting areas of Leh and Kargil district is given in Table 1. Total cropped area in proportion to reporting area was more than double in Kargil district as compared to Leh district. A very small patch of good forest land has been reported from Kargil district. However, there was no forest in Leh district. Land under non agricultural uses was much higher in Leh district as compared to Kargil district, which indicated better infrastructure facilities in Leh district. Grazing resources as per reporting area was much higher in Leh district however, percentage in comparison to reporting area of the district, the grazing resources was slightly less in Kargil district.

Table 1 Land use pattern in Ladakh region during 2009-2010 (area in ha)

Land use	Leh district	% of total reporting area	Kargil district	% of total reporting area
Reporting area	45579	100	20381	100
Forest	0	0	64	0.3
Land under non agricultural use	28071	61.6	5754	28.2
Permanent pasture/ Grazing lands/Area under tree and grooves/ Cultivable waste	6473	14.2	3414	16.8
Fallow lands including current fallows	427	0.9	465	2.3
Total cropped area	10608	23.3	10684	52.4

Methods

Three important issues viz., significance of livestock cold arid regions, fodder base in cold arid regions and a case study of a village in Leh has been discussed in the paper. For analyzing significance of livestock in and fodder base in cold arid regions range of available literature and livestock population census of the region were consulted. In addition, the results of preliminary work carried out at ICAR-CAZRI, Regional Research Station Leh is included while describing fodder base in cold arid region. For case study to work out fodder and crop production and its energetics in a village following methodology was used. Village Nang was selected for the study. At first instance, secondary data regarding village land use pattern, human and livestock population, etc. were collected from revenue department of Leh administration. A survey of 40% households (67) of the village, selected randomly was carried out and a questionnaire completed providing information on food and fodder crops and vegetables grown, cultivated area under different crops, labour input of human and dzos in terms of man days and Dzo-days, respectively, seed input, manure input, input of crop yield increasing chemicals, crop yields, yield of by-products, sources and requirement of fire wood for man, sources and requirement of fodder for livestock. The approach is similar to Tewari JC et al.² Further, repeated field checks were also made to determine the input of manure and yields of crop and straw. The data so collected from the village have been used to compute energy budget of the crops grown. Input and output values were converted using calorific equivalents as reported by Mitchell R.³ Energy budget calculated separately for each crop and also for fodder available from the system in form of fodder crop alfalfa, crop straw and vegetable residue.

Results and discussion

Significance of livestock in cold arid regions

Animal husbandry forms an integral part of farming as these not only substantiated the sources of livelihood, but also ensured sustainable maintains of soil fertility, through addition of farm yard manure and by providing draft force for farming as well as transport. While majority of farmers follow mixed farming, 'Changpas' who inhabit *Changthang* area of Leh district follows a nomadic life; always moving in search of greener pastures to ensure continuity to their livelihood source in one of the environmentally harshest areas of the country. Livestock manly consists of yaks, dzos, dzomos, horses, Pashmina sheeps, goats, few cows, donkeys and very few double humped camels. As per the local herders, yaks have increased in recent years. This is probably a result of minimal demand of labour for yak rearing, as they could be left untended in the high pastures, sometimes even during winter. Nevertheless, the increased threat from wolf has concerned the pastoralists over the years. Thus, the trend may reverse toward more Pashmina goats, which are tended in the high pastures and more importantly have high demand in the *Pashimna* and meat market.⁴ The importance of livestock in Ladakh is manifested by the fact that in the region the livestock population is almost thrice the human population, which attests the theory that earlier settlers were pastoralists. The barrenness of the land and soil texture demand use of large quantities of FYM to raise any crop, which can be obtained only from the livestock as no other compostable material is available. The population of livestock in Ladakh region during 2009-2010 is set in Table 2.

Table 2 Livestock population of Ladakh (2009-2010)

District	Leh	Kargil
Cattle	36231	46206
Zo/ Zomo and Yaks	22915	21154
Sheep	99599	179306
Goats	259013	98614
Horse, ponies, Donkeys and Mules	13713	12181
Camel	164	-
Total	431635	357461

If we see the total human population in these two districts, it was only 236539, which indicated that at present livestock: human population ratio in Ladakh is 1.0:3.3. From the data available, two contrasting trends emerged in recent past in sheep and goat population in Leh and Kargil district.⁴ There is decrease in population of sheep and goat (non Pashmina) in Leh district, however 10% increase was observed in case of Pashmina goat population. In Kargil district, sheep and goat population has shown a continuous increasing trend, which can attributed to increase in demand for meat. Backyard poultry has suffered seriously in Leh district with present population of 3206 birds however, in Kargil district the population of poultry birds remain more or less stable with present population of 46000 birds. Sheep and goat pastoralism is a constant feature of traditional mountain societies. There are nomads like Changpa of Changthang in Ladakh, whose economy is predominantly based on animal husbandry; there are agro-pastoralist groups who practice marginal agriculture and raise herds of sheep and goats and yaks.⁵ Transhumance with or without agriculture becomes profitable where high pastures are available. In Ladakh transhumant like, Changpa of Changthang migrate from summer pastures to lower altitude where fodder is available in winter with their flocks have some sort of living arrangement at both the places and use tents as shelters during ascending or descending. Among the agro-pastoral groups, although agriculture provides the bulk of staple food, they give major importance to the care and value of the sheep and goat. From animals they obtain additional food in the form of meat and milk, wool for clothing and cash for buying other necessities.

Pastoral cycle of changpas

Mechanism of movements is very vital for pastoral communities to achieve a balance in man- livestock-pastures other vegetation continuum, which was described very precisely by Bhasin V.⁶ Movement trends of the Chang pas consisted of fixed spatial movements and flexible sequential movements. These movements are regular and cyclic between the areas of summer pastures other vegetation complex and winter pastures. This indicated that areas used for grazing remained same year after year. Each movement coupled with stay at a place depended on the availability of grass other vegetations and water. As soon as Changpas noticed the reduction of water and shrinkage of pasture other vegetation, the information is conveyed immediately to the goba (headman/leader). Apart from the availability of water and pasture/other vegetation, the Changpas also changed sites due to festivals, social gatherings and localised drought. It was observed that some time Changpas moved from one site to other due to outbreak of disease. The decision of breaking a camp was taken in advance by goba and his advisory committee. Often goba organized a meeting and explained the reason for the next move.

Once goba ordered for the move, each family started preparing for it. The Changpas started moving with their bag and baggage i.e. tents, stove, food, clothes, carpets, other household items, etc. Changpas always kept some extra food and equipments not needed immediately in the store houses of their winter villages. Before moment to next site some Changpas have been sent to collect yaks and horses pasturing in the higher valleys. The yaks are rounded up and loaded. They take out all the necessary items required for day to day living. One yak exclusively carried a steel trunk which contained religious objects and religious books/other literatures. The yaks are driven in front, followed by the women and children. The men in the rear led the horses. The Changpas were found to move from the camp early in the morning and reached the new camp site generally by noon. As the Changpas move in groups, the individual difficulties or circumstances of a household did not count. Changpas were observed to complete the journey to next camp site in two stages.

The first batch left the camp two days before the rest of the camp followed. In the first batch, each family sent a part of their belongings with two or three family members to the new camp site, the rest tagged along on the selected day. This protocol was observed to ease the situation for families, who do not had enough yaks and horses to carry their possession in one go. Out of two three family members, two will stay at the new camp site to guard the possessions and one returned with yaks and horses for the next round. The tents are pitched at new sites in cooperative mode by the community members for different families. The tents are pitched besides the pens meant for livestock. The enclosure and pens were private properties of the individual household. They belonged to people who built them. During migrations, the staple diet of the Changpa remained milk and milk products (curds, buttermilk, butter, cheese and whey), meat (including blood and organ meat) and *Tsampa* (roasted barley flour).

From above discussion it has been clear that how important livestock sector is as one of the key components of livelihood and economy of cold arid regions of India. The cold arid region livestock system is the endeavor of small holders in one way or other however, this sector is lifeline of rural population and as well as transhumant population, who are solely dependent on their livestock production systems.

Fodder base in cold arid regions

The grassland vegetation in the Indian Himalaya occupies nearly 35% of the geographical area and includes the warm temperate grasslands, sub-alpine and cool temperate grassy slopes, alpine meadows of the greater Himalaya and the steppe formations of cold arid regions or alpine dry scrub. These grasslands form distinct categories of their own and differ from one another in terms of origin, structure and composition.

Five grassland types are defined and described: warm temperate grasslands; cool temperate grassy slopes; sub-alpine meadows; alpine meadows; and steppe formations of the trans-Himalaya.⁷ Steppe formations of trans-Himalaya, the cold arid regions are characterized by the Mediterranean type of vegetation, i.e. scattered low shrubs with sparse grasses and forbs. Several communities are reported from the cold arid regions of Ladakh and Spiti regions of north-west Himalaya, e.g. *Artemisia-Caragana*, *Ephedra-Juniperus*, *Salix-Myricaria* and *Lonicera-Rosa*. Cold desert of great Himalaya have only short-lived species, which provide 2-3 months grazing during summer. Several indigenous species of grasses (*Agropyron sp.*, *Agrostis sp.*,

Alopecurus sp., *Bromus sp.*, *Cicer sp.*, *Lespedeza sp.*, *Artemisia sp.*, *Oryzopsis sp.*, *Lolium sp.*, *Medicago spp.*, *Melilotus sp.*, *Trifolium sp.*, and etc. species) are found in Ladakh region. A potential hay species *Pronges pabularis* is identified in recent time, which able to produce 1 to 1.5t/ha of herbaceous fodder with 10.4 per cent of crude protein. However, in many places it has been observed that now *Carex* species, which is a coarse and unpalatable grass is gradually replaces nutritive palatable ones. This clearly indicated that grasslands/pastures in cold arid region are gradually depleting. In addition to grasses in Ladakh region, nature has provided some plant species viz. *Caragana pygme*, which is a leguminous thorny bush in Changthang region. The leaves of this bush are good source of fodder especially, when surface is covered with snow.⁸ This plant also serves as a source of fuel.

To sustain such heavy livestock population in Ladakh area require huge amount of fodder supply. The data/estimates of fodder production in the country vary widely. Fodder production and its utilization depend on the cropping pattern, climate, socio economic conditions and type of livestock. The cattle and other livestock in villages are normally fed on the fodder available from cultivated areas, supplemented to a small extent by harvested grasses and top feeds. The three major sources of fodder supply are crop residues, cultivated fodder and fodder from common property resources like forests, permanent pastures and grazing lands. The regional deficit is more important than the national deficit, especially for fodder, which is not economical to transport over long distances. The pattern of deficit varies block to block of the region. For instance, the fodder availability in cold arid regions is 40-50% of the actual requirement however, in some valley areas it is below 40%.

In animal feed supply, cereals have a major role. Major cereals in the region are wheat, barley, and other millets. Production of these cereals is declining day by day.⁹ Although, cold arid regions have many perennial, annual grasses and palatable shrubs as natural vegetation resources but they are confined to little pockets especially, in lower altitudinal part and valleys. Ladakh has been divided into three major belt viz., very high altitude zone (6000 m and above) central belt, like Changthan belt (4500- 6000 m) and lower valleys and river side areas (less than 4500m). In central belt, the fodder alfalfa (rich in nutrient content) was being grown as secondary crop up to recent past and only to the rejected areas (Figure 1). Now it has established as main cultivated fodder species supplemented by wheat and barley straw. During the survey made by CAZRI at Saboo village, Leh, It was recorded that these crops are sown at higher seed rate as compared to normal/recommended rate so as to obtain good amount of crop residues for fodder during winter.⁹ Few amount of weeds after manual weeding (at 30days after sowing) from crop fields are also realized as fodder. Good part of growth of alfalfa fodder is lost as the regenerating crop in its early stage (April-May season) is grazed by animals except in fenced areas. It has been observed that the animals are let loose for grazing the fields and as a result alfalfa faces a huge loss in its total production. Thus, alfalfa and crop residue are major parts of fodder base in cold arid region of India.

Benefits of alfalfa (*medicago sativa* and *M falcate*) cultivation:

- i. Fodder yield is comparable to any other forage crop in terms of both quantity and quality.

- ii. It acts as a soil binder, thus reduce soil erosion
- iii. Improve the physical and biological properties of soil.
- iv. Efficient nutrient utilizer as it draws nutrient and moisture from deeper layers of soil.
- v. Being perennial, needs less agricultural operations from second year onwards.
- vi. Cost of cultivation is low as manorial requirements are nominal after first year.
- vii. Provides highly nutritious fodder to animals that can replace feeding of grain or concentrate to animals.
- viii. Can be cultivated as bonus crop in apricot and apple orchards.
- ix. Serves as a source of nectar to many insects.
- x. Successfully tides over short period of draught.
- xi. Spreading plant type act as cover crop and reduce water losses due to evaporation and
- xii. Diseases and pest management is required in a very low level.

The yield level of Alfalfa varies from place to place however, on an average it produces 6.0-7.0 t of green fodder (2-3 t of dry fodder). The grain yield on an average ranged from 0.15 to 0.2 t/ha. Alfalfa fodder has 12.5-23.9 % crude protein, 0.3-0.4 % phosphorus, 1.5-2.5% potassium, 0.9-2.0% calcium and 0.05-0.2% sodium. It is also very rich in vitamin A, B and D. Double cut varieties of this species are available, first cut after 50-55 days of sprouting (mid June) and second and final cut is taken at maturity (mid-September).



Figure 1A-D: Some views of fodder base at cold arid region of Ladakh. **Crop residue and it's importance as fodder**

Wheat, native barley, millets and pulses are grown as a summer crop in cold arid region. The area is single cropped and wheat and native barley straw are other important source of dry fodder in the region (Figure 2). In addition, vegetative parts of pulses and millets, which are available in very low quantity also form minor source of fodder to livestock. In fact, dry straw of wheat and native barley and with dried alfalfa are stored generally on roof tops of houses in the winter. These are the main fodder source for lean periods. Placing the bundles of crop straw and dry alfalfa also provide some heat to houses during severe winter cold.



Figure 2 Bundles of harvested crop field of a village.

Case study of a village of Leh

Situated at 30 km from Leh (Indian cold arid region) in deep eastern valley at left side of Leh-Manali highway, Nang is a small village which is dependent on glacier recharge for water. A study was conducted in this village to understand the fodder production from crop fields. Being cold arid region, the temperature ranges is between -35°C in winter to $+35^{\circ}\text{C}$ in summer. In general, area has short mild summer to long cold winter. Mean precipitation ranged between 100-120mm, the major portion of which comes in form of snow fall. Potential evapo-transpiration was in order of 700-800mm per year. The growing period varies from location to location, ranging from 80 to 150 days (from mid April to August). At first instance, secondary data regarding village land use pattern, human and livestock population, etc. were collected from revenue department of Leh administration.

Total human population of village Nang was 288 and that of livestock (dzo/dzomo, bullock, yak, sheep and goat) was 384. Livestock population/ha of cultivation was recorded 27.00. Human population/ha of cultivation was found 20.00. Thus, human: livestock ratio was 1:1.3. Crop productivity including crop straw/vegetables residue production is set in Table 3. It is supposed that crop straw/vegetables residue is completely used as a fresh fodder for livestock.

As per the estimate total fresh fodder requirement of 27livestock/ha was 63510kg/year. However, available production of crop straw/vegetables residue was only16910.4kg/ha/year. This indicated that there was a deficit of 46600kg/ha/year. This deficit comes to the tune of 73% at village level. Now the question is how such huge deficit fodder requirement is met by livestock keepers of villages. A substantial quantity of fodder is supplied by extra territorial collection and free grazing of livestock on village common lands and lands not available for cultivation (including permanent fellow lands), which constituted approximately 57% of total village area i.e. 127.5 ha. Studied clearly indicated that huge fodder deficit existed in this part of country as far as village level fodder production is concerned. Huge deficit of fodder at village level itself explain great significance of high altitude pasture lands. Other vegetables mainly include spinach, cauliflower, cabbage, tomato, French bean, brinjal, radish, carrot and chili.

Energy budget of different crops in village Nang is set in Table 4. The energy input and output ratio was in positive side only for cereal crops. In case of all other crops including fodder crop alfalfa the input of energy was much more than the output. This indicated that crop production system in general is not efficient from energetic point of view. High quantum of crop straw production was observes in case of cereal crop barley and wheat but irony is that gradually the area of cereal crop is decreasing year by year in cold arid region of Ladakh.⁹ In terms of energy output, the higher values were also obtained for cereal crops. Though energy output values for fodder was maximum for alfalfa, a unique fodder species for the region but it required very high amount of inputs in comparison to cereal crops which provide ample amount of fodder in form of crop straw. Fodder energy output from other cash crops viz., onion, potato, pea and other vegetables was of very low order. This scenario indicated that there is urgent need to increase the area of cereal crop and fodder crop alfalfa cultivation as they are an important source of fodder in this part of the country. Together with on farm fodder supply system and pastoral fodder supply system, the fodder deficit could be reduced if both fodder supply components could be strengthened through appropriate technological interventions.

Table 3 Crop and crop straw/vegetables residue productivity in village Nang

Crop	Village nang			Manure used (kg ha ⁻¹)
	Seed input (kg ha ⁻¹)	Yield output (kg ha ⁻¹)		
		Grain/commodity	Straw/vegetable residue	
Barley	155.2	708.9	1426.4	387.8
Wheat	287.4	1084.1	1821.5	383.3
Pea	430	2011.3	987.3	6261.7
Tuber (Mainly Potato)	1390.7	12250.5	1677.3	58125.5
Other Vegetables*	1.2	1146.5	467.1	3921.6
Onion	2.5	3927.8	414	3711.3
Alfalfa (Fresh)**	-	-	10116.8	3316.1

*Other vegetables mainly include spinach, cauliflower, cabbage, tomato, French bean, brinjal, radish, carrot and chili.

**Alfalfa is a perennial fodder crop.

Table 4 Energy budget of different crops in village Nang (unit in each case=value X 105K cal/ha/year)

Particular	Barley	Wheat	Pea	Potato	Onion	Other vegetables	Alfalfa
Input							
Human Labour	0.2	2.2	1.1	4.6	0.8	1.1	4.8
Dzo labour	2.6	2.8	1.6	6.6	0.9	1.2	1.6
Seed	6	11.1	17.5	13.1	0.1	0.1	-
Manure	15.8	15.6	225.1	236.8	151.2	159.4	135.1
Fertilizer	-	-	-	-	-	-	-
Total	24.6	31.7	245.3	261.1	153	161.7	141.5
Output							
Arable crop/commodity yield	27.4	41.9	81.8	115.4	37	10.8	95.3
Crop straw/ vegetable residue	47.5	70.4	9.3	15.8	3.9	4.4	-
Total	74.9	112.3	91.1	131.2	40.9	15.2	95.3
Out: Input ration	3	3.5	0.4	0.5	0.3	0.1	0.7

Future scenario

Average deficiency of 40-45% fodder is the major constraint for livestock production systems of cold arid regions of Ladakh. In fact, shortage of alfalfa and receding area of cereal crop production is the main bottle neck for fodder supply to livestock production. In one hand the area of cereal crops is decreasing with very rapid rate and in case of alfalfa seeds of the species are being imported and they face difficulty in adaptation due to severe winter and other climatic and edaphic factors. On the other hand, farmers prefer to harvest alfalfa crop for fodder rather for seed collection due to acute shortage of labour. However, there is an urgent need to bring alfalfa in large scale cultivation to produce seeds locally at least in new command areas. Alfalfa seeds are costly, but climatic conditions are congenial for alfalfa seed production. Large scale local seed production of alfalfa will go long way to solve the fodder deficit in the region. Energy budget of different crops at least for fodder produce indicated that it is also essential to enhance production of cereal crops as their straw provide good source of fodder for livestock with less energy input.

Pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic changes in Ladakh need immediate attention and implementation of appropriate developmental schemes for fodder production in local scale. Climate change induced hazards such as floods, landslides and droughts will also impose significant stresses on the livelihoods of mountain people and livestock production. Society will need to improve its adaptation strategies by strengthening folk knowledge, innovations and practices within socio economic cultural fabric and environmental condition of the region. The location and area of natural vegetation zones may change under projected climate change scenarios. Climate change may also result in a shift of the boundary of the farming pastoral transition region. However, the transition area of the farming pastoral region is also an area of potential desertification.

Conclusion

The importance of high mountain ecosystems and communities has only recently been recognized in the world development agenda. Water resources, biological and cultural diversity, specific agro pastoral

economic systems and the conservation of heritage of recreational and spiritual significance are key issues related to sustainable mountain development. Understanding of the environment and a vast body of traditional knowledge systems have enabled mountain people to plan and implement activities, such as traditional land and livestock management practices that are still fundamental for low intensity production systems at high altitudes. Short term development programs and projects which overtly reject the knowledge of local inhabitants, insufficient acknowledgement of the scarcity of local resources, as well as the mismatch between "mountain specificities" and human driving forces lead to local environmental degradation and long-term un-sustainability.¹⁰ The concept is also true for pasture development and fodder production strategies in cold arid regions of Ladakh. Therefore, the immediate focus is required for regeneration of pasture lands and increase in alfalfa and cereal crops production areas. Willow and Poplar are only two tree genera quite adaptable in mid-high altitude areas and lower valley parts of Ladakh. They should be given prime importance through plantation forestry and agro-forestry programmes. Many species of willow provide excellent leaf fodder in addition to wood for fuel and minor agriculture implements. The production systems in the villages should be in form of diversified farming systems in man-livestock crop fodder continuum.

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Conflict of interest

The author declares no conflict of interest.

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