G.B. Pant Memorial Lecture - 2025

Memorial Lecture: XXXI

Dr. G.S. Rawat

September 10, 2025

at Kosi-Katarmal, Almora

G.B. Pant National Institute of Himalayan Environment (NIHE)

(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Govt. of India)

Kosi-Katarmal, Almora, 263 643, Uttarakhand, India

Dr. G. S. Rawat

Dr. Gopal Singh Rawat, formerly Dean and Director at the Wildlife Institute of India Dehradun, has been actively engaged in teaching, research and academic activities since last 45 years. His areas of specialization include eco-floristic studies in the Himalayan region, Ecology and Management of Alpine rangelands, Status survey of medicinal plants, and Wildlife Habitat Wildlife Ecology. He has Ph. D. and D. Sc. degrees in Botany from Kumaun University Nainital. He has over 325 publications including peer reviewed papers, books, reports and popular articles on a wide range of topics including plant systematics, habitat ecology and management of wildlife habitats in India. He has guided more than 35 Ph. D. and 15 Masters' students. In the year 2004, he led an ecological expedition across alpine region of Western Himalaya from Indo-Nepal Border to Holy Amarnath and documented the status of alpine meadows, wildlife habitats and high value medicinal and aromatic plants along survey route. His other experiences include working as Chief Scientist, Ecosystem Services at International Centre for Integrated Mountain Development (ICIMOD) at Kathmandu (2011-14), Member, Task Force on Mountain Ecosystems for the Planning Commission during (2006-08), Member of IUCN (SSC) Orchid and Medicinal Plant Specialist Groups and an expert member, Intergovernmental Panel on Biodiversity and Ecosystem Services for the Asia-Pacific region. Currently he is a member of the Planning Board for Union Territory of Ladakh and member of expert committee for the management of Invasive Alien Species in India and Plant Conservation formed by the Ministry of Environment, Forest and Climate Change, Govt. of India. He served as a Chairman of the Committee for formulation of Rangeland Policy for the Union Territory of Ladakh.

Dr. Rawat is Fellow of National Academy of Sciences, Allahabad (2004), Fellow of Linnean Society of London (2023) and Fellow of National Institute of Ecology (2024). He is also recipient of prestigious T.N. Khoshoo Memorial Award (2019) for his work on orchids of Uttarakhand and Paul Stuessy award of for his work on Alpine Plant Systematics and Ecology.

G.B. Pant Memorial Lecture - 2025

Memorial Lecture: XXXI

Dr. G.S. Rawat

September 10, 2025

at

Kosi-Katarmal, Almora

G.B. Pant National Institute of Himalayan Environment

(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Govt. of India)

Kosi-Katarmal, Almora, 263 643, Uttarakhand, India

Rangelands of Indian Trans-Himalaya: Sustaining Ecosystem Services and Pastoral Livelihoods

Dignitaries, Distinguished Guests, Director, G.B. Pant National Institute of Himalayan Environment, One and all in the NIHE Family and Friends from the Media:

It is a matter of immense pleasure and privilege for me to deliver 31st Pt. Govind Ballabh Pant Memorial Lecture on the occasion of this Institute's Annual Day. At the outset I thank the Institute for giving me this honour. Before I proceed further, I pay my humble tribute to Bharat Ratna, Pt. Govind Ballabh Pant on his birthday. We all are aware, he was one of the key figures in India's freedom movement and a visionary leader who hailed from this very place.

This lecture is entitled, "Rangelands of Indian Trans-Himalaya: Sustaining Ecosystem Services and Pastoral Livelihoods". I shall give a brief background of the Indian Trans-Himalaya, changing trends in pastoral practices in the region, major issues and challenges, and key strategies for sustaining ecosystem services for human wellbeing. The presentation is based on empirical evidences, my own experience of ecological surveys in alpine arid rangelands of Indian Himalayan region during past four decades and published literature. I would be happy to take questions and comments at the end of my talk.

***

1.0 Background

Volumes have been written and spoken about significance of the of Himalayan mountains as global assets, water towers of Asia, sentinels and refugia for climate change and most importantly, sources of numerous ecosystem services to the millions of people living within the region as well in downstream areas. These services, if valued, harnessed and shared equitably, would form the backbone of sustainable development and human well-being in the region. Undoubtedly, the national and state governments have been engaged in advancing the sustainable development goals (SDGs) in the region particularly in the area of rural development, food security, water and climate action. Likewise, a large number of institutions and individuals are pursuing research on various themes and generating relevant knowledge, tools and techniques for achieving SDGs in the region. When it comes to research on sustainable development in the Himalayan region, we are reminded of the seminal work by one of the scholars of mountain farming systems, Dr. N.S. Jodha, who suggested a framework based on mountain specificities (Jodha 1992). He highlighted the need to understand the unique features of mountain ecosystems that pose challenges as well as opportunities for sustainable development. According to him, the main constraining specificities in the mountains are inaccessibility, fragility and marginality while enabling features include diversity, niche opportunities, adaptive capacity and resilience of the local communities. Dr. Jodha further explained that the specificities are not static and can change with the passage of time under globalization, climate change, and policy

interventions. Hence development strategies need to be adaptive and responsive to such evolving conditions.

The contemporary literature on the Himalayan environment tends to generalize many issues without specifying the sub-regional specificities and socio-ecological conditions. Talking of Indian Himalayan Region (IHR), one needs to recognize four distinct sub-regions, viz., North-eastern Hill states, Himalaya and Trans-Himalaya. Here I refer to the Indian Trans-Himalaya that lies in the rain shadow zone of the Greater Himalaya and often described alpine arid ecosystems or cold deserts. This region forms a distinct biogeographic zone comprising four biogeographic provinces viz., Ladakh mountains, Changthang plateau, Trans-frontier areas of Himachal Pradesh and Uttarakhand and Sikkim (Rodgers and Panwar 1988; Kumar et al., 2018). It is not only fascinating due to its unique ecological, socio-cultural and geo-hydrological features but also very sensitive geopolitically. Generally located above 3000 m (mean elevation being about 4500 m asl), the region is marked by extremely harsh climatic conditions, sparse vegetation cover, short growing season and low primary productivity. Yet, it provides a wide array of ecosystem services. The key provisioning services from the region include rangeland resources that contributes to the local economy and have sustained the agro-pastoral communities since ages (Murali et al., 2017). At the same time, this area is home to a large number of globally threatened species of flora and fauna. Besides, the region forms the upper catchment of all the rivers and streams in the region which eventually benefit all the downstream communities and harbours a large number of high value medicinal and aromatic plants (MAPs).

What are the key features of the rangelands in Indian Trans-Himalaya? What are the critical ecosystem services flowing from these rangelands? What are the key issues and challenges in sustainable management of rangelands? How to manage rangelands for sustaining pastoral livelihoods and multiple functions for long term human well-being in the region under changing climate, globalization and increased accessibility? and What would be the best way forward for integrated conservation and development of the alpine arid rangelands? These are the key questions addressed in the following sections.

2.0 What are the key features of the trans-Himalayan rangelands?

Unlike the alpine ecosystem of Greater Himalaya, the Trans-Himalayan or alpine arid rangelands represent much older ecosystem originated nearly 50 million years ago during Miocene collision of the Indian and Eurasian Plates. After the final phase of Himalayan uplift and rain shadow effects of Greater Himalaya, the alpine arid regions gradually transformed into rugged mountain slopes, river valleys, inland lake basins and vast undulating plateau. These regions are sparsely vegetated in the form of desert steppe, scrub steppe, high alpine grass and sedge dominated communities. Presence of a wild bovids such as wild yak (*Bos grunniense*), equids such as Tibetan wild ass (*Equus kiang kiang*), several wild caprids in the region indicates intimate co-evolution of graziers and graminoids. It is in these ecosystems the yaks and caprids got domesticated and thrived over the millennia. Present day trans-Himalayan rangelands thus comprise numerous wetlands, remnant palaeo-lake basins and retreated Tethyan sea beds. Over 80% of the land mass in this region is uncultivable. The native agropastoral communities have used these areas for livestock grazing since centuries. These communities have inherited extremely rich culture and traditional ecological

knowledge pertaining to sustainable living. So far, they have lived in harmony with nature as evident by the presence of rich flora and fauna including several endemic and globally threatened species. Key features within the sub-region are given below:

2.1 Ladakh

The sacred land of Ladakh, now a Union Territory of India, is located between the Great Himalayan range in the south, Karakorum range in the north, Pakistan in the west and Tibetan Autonomous region of P.R. China in the east. It has a wide altitudinal range from 2550 in western Ladakh to 7672m asl (Saser Kangri in Karakorum range). Ladakh is divisible into four socio-cultural regions, viz., (i) Western Trans-Himalaya covering Lower Indus, Surru, Drass and Zanskar ranges, (ii) Central Ladakh including Stok and adjacent region and river valleys including central part of Indus, (iii) Karakorum range including Nubra-Shyok region Daulatbeg Oldi and Depsang plais and (iv) Changthang covering Samad, Nyoma and Durbuk blocks. Livestock husbandry has been one of the primary sources of livelihood for Ladakhis. The region is home to several breeds of livestock including Pashmina goat, Purik sheep, yak, Bactrian camel, Zangskar and Chumur horses having high conservation significance and have tags of geographical indicators (GI).

The rangeland vegetation in Changthang is represented by desert steppe, scrub steppe, alpine moist meadows, marsh meadows and riverine scrub. Of the various classes, the desert steppe is by far most extensive covering much of the alluvial banks of major rivers and sandy plains. One of the key features of rangeland vegetation in Ladakh is alpine marsh meadows which form only about 2-3 % of the vegetation and have relatively low standing biomass (31.99 g m-2). Yet such areas support a considerably high livestock especially during winter months. They also serve as crucial breeding areas for migratory birds such as black necked crane during summer (Mishra et al., 2001). Hence these areas assume highest conservation significance. Rocky and scree slopes above 5000m in Changthang and Karakoram supports very sparse (< 5%) vegetation cover. Characterisitc species are *Carex nivalis,* species of *Leontopodium, Melica, Christolea, Rhodiola, Draba,* and *Saussurea*. Moist and stable slopes have cushion-like growth forms e.g., *Thylacospermum caespitosum, Arenaria bryophylla, Androsace aizoon* (Rawat & Adhikari 2005).

Associated with pastoral practices are a number of local socio-cultural traditions and customs unique to various sub-regions. The rangelands in Ladakh are also home to a number of spectacular and threatened animals such as endangered snow leopard (*Panthera uncia*), Pallas's cat (*Otocolobus manul*), Tibetan wolf (*Canis lupus chanco*), Tibetan argali (*Ovis ammon hodgsoni*), Ladakh uriyal (*Ovis vignei vignei*), Tibetan antelope (*Panthelops hodsonii*), Tibetan gazelle (*Procapra picticaudata*), wild yak, black necked crane (*Grus nigricollis*) and Eurasian Lynx (*Lynx lynx*). These species have so far co-existed with the pastoral and agro-pastoral communities.

The rangelands of Ladakh store a considerable amount of soil carbon despite low sequestration potential. However, rate of sequestration and storage varies considerably depending upon the slope, aspect and altitude. Generally, rate of carbon sequestration decreases with increasing altitude and aridity. However, detailed information on these aspects is not available from Ladakh. Studies have shown that alpine meadows, alpine desert steppe, grasslands and scrub steppe accumulate a considerable biomass and the alpine sedge meadows (peatlands)

serve as important C sink and deserve special efforts to conserve. Most of the land in eastern and northern Ladakh also falls under protected area (PA) network (Fig. 1), as a result there has been an increasing conflicts between the PA management and local herders. Currently, the UT Administration of Ladakh is in the process of rationalization of PA boundaries.

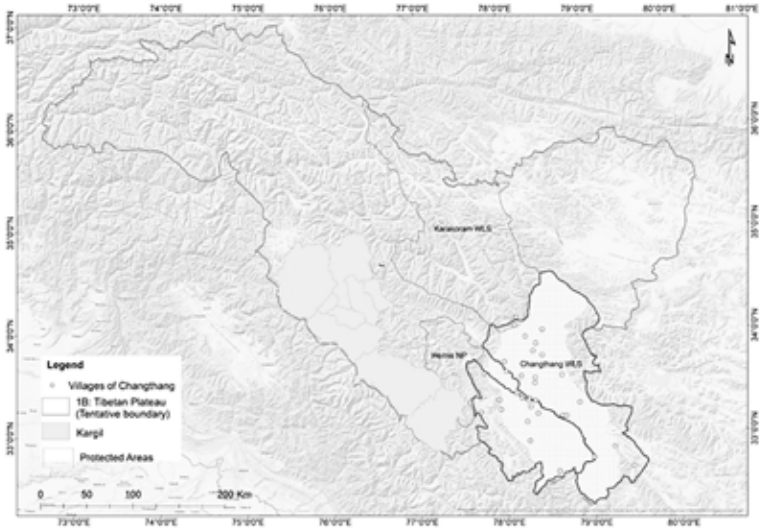

Fig. 1. Protected area network in Ladakh where livestock as well as wildlife are pervasive.

2.2 Alpine arid rangelands of Himachal Pradesh

North-eastern part of Lahaul, entire Spiti sub-division and Pooh sub-division of Kinnaur district represent cold desert ecosystem in Himachal Pradesh that spans over nearly 12000 km2. Physically this area is contiguous with Ladakh and characterized by sparse vegetation cover typical of cold deserts. The landscape is a mixture of broad valleys (e.g., Sarchu Plains, Upper Spiti), plateau (Kibber) and rugged mountain slopes (Lahaul and Kinnaur). This region is comparable with Ladakh in terms of flora and fauna represented by over 700 species of vascular plants including a large number of high value medicinal and aromatic plants. Generally the vegetation cover is very sparse comprising riverine scrub dominated by *Hippophae tibetana* ssp *turkistanica* and *Myricaria elegans*, *Salix* spp., scrub steppe, mixed herbaceous meadows and few patches of sedge meadows. The scrub vegetation is dominated by *Caragana versicolor* and *Krascheninnikovia pungens*, *Ephedra gerardiana – Lonicera spinosa, Artemisia – Potentilla* etc.

Several species of fauna that are on the Red List of IUCN as Critically Endangered Species are found here such as the snow leopard, Himalayan wolf. Other species of fauna include woolly hare, Himalayan brown bear (*Ursus arctos*), red fox, Himalayan ibex (*Capra ibex sibirica*), Himalayan marmot (*Marmota himalayana*), Himalayan blue sheep (*Pseudois nayaur*), red billed chough, Chukar partridge, snow partridge, blue rock pigeon, snow pigeon, Himalayan snowcock, lammergeier, Himalayan griffon, golden eagle, and rosefinch. Sutlej gorge serves as biogeographic barrier for Himalayan ibex which does not extend east of this river. Some of

the mammals such as Tibetan wild ass, Tibetan sheep, Ladakh Urial and Tibeten antelope and Tibetan gazelle are totally absent in Spiti.

Spiti is regarded as one of the important geo-heritage sites owing to its sequence of exposed sediments from the Pre-cambrian era to the Cretaceous period, characterised by sharp changes in a combination of quartzite, shales, limestones and conglomerates. Most of the area is rich in fossils, mainly brachypods, trilobites, ammonites, bivalves and also certain corals and algae, indicating its Tethyan past. Spiti is also characterized by the presence of three large glaciated blocks viz., Bara-Shigri complex, Gya massif to the northeast and Manirang peak to the southeast. Part of the landscape rich in wildlife has been designated as Upper Spiti Landscape (Fig. 2) for which an integrated wildlife management plan exists (Anonymous 2011). The herders from Kinnaur practice nuclear transhumance and use the pastures of Raksham Chitkul Wildlife Sanctuary, other pastures of lower Spiti.

2.3 Alpine arid rangelands of Uttarakhand

The Uttarakhand Trans-Himalaya forms a narrow belt along the northern flank of the state immediately north of main central thrust of Greater Himalaya. There are four major valleys representing the cold desert ecosystems similar to Ladakh and Tibetan Plateau in terms of geology and biophysical features, viz., Nilang Valley located in upper catchment of Jad Ganga (Jahnavi) in Uttarkashi district, Inner ranges of Alaknanda and Niti and Girthi valleys in Chamoli, Upper Johar, Darma and Byans valleys in district Pithoragarh (Fig. 3). Nilang is connected with Kinnaur on the west and forms contiguous habitat with Tibetan plateau. It falls in Gangotri National Park.

The upper catchments of Alaknanda, Western Dhauli and Girthi rivers form the north-eastern flank of Nanda Devi Biosphere Reserve. Geologically these areas represent two different structural formations viz., crystalline rocks of Vaikrita Group and the sedimentary thick sequence of Tethyan Himalaya. The landscape beyond Sumna especially towards Lapthal and Sangcha exhibits astounding geo-morphological features comprising complex fossiliferous strata of marine fossils ranging in

Fig 2. Map showing Upper Spiti Landscape and adjacent areas

age from Precambrian to Mesozoic sequence and deserves national recognition as 'geo-heritage site'.

The upper catchments of Gori, Eastern Dhauli of major taxa. Riverine scrub is represented at lower elevations by *Myricaria elegans* and *Salix oxycarpa* and towards higher altitudes (>4000m) these habitats are dominated by *Myricaria prostrata* and *Salix sclerophylla*.

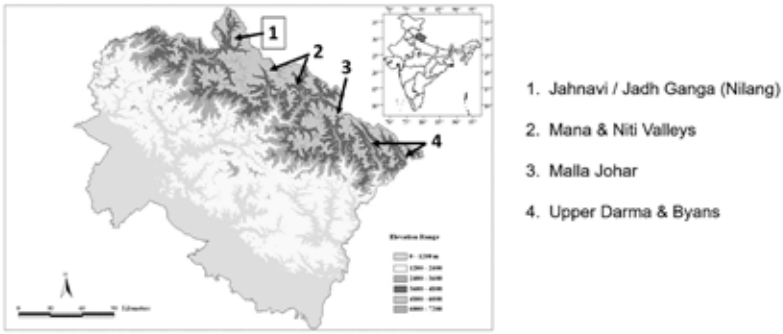

Fig 3. Trans-Himalayan valleys of Uttarakhand

(Darma Ganga) and Kali - Kuti rivers exhibit a gradual transition from moist alpine to dry alpine ecosystems. Since these valleys are very close to Great Himalayan range and receive higher precipitation as compared to Nilang and Western Dhauli, they support higher vegetation cover and greater species diversity (Rawat 2007).

All the four trans-Himalayan valleys in Uttarakhand have been used by the local and well as migratory pastoral communities from the lower districts since several centuries. Major classes of vegetation in these rangelands include scrub steppe, alpine marsh meadows, mixed herbaceous formations, fell-field (cushionoid vegetation) and moss-lichen communities in the sub-nival zone. The dry alpine scrub is further divisible in to 3 -4 distinct communities viz., *Caragana gerardiana – Artemisia brevifolia, Artemisia – Lonicera spinosa, Dasiphora arbuscula* mixed and *Caragana versicolor – Krascheninnikovia ceratoides* with local variations in the abundance Of the various communities in the cold deserts the sedge meadows in the upper and lower Lapthal are most interesting on account of their oasis like formations which are dominated by sedges and a few grasses. Sedge meadows also support a large number of associated herbs including species of *Astragalus, Oxytropis, Potentilla* and *Carum carvii*. These meadows are much favoured for grazing by domestic livestock. Uttarakhand Trans-Himalaya share close affinities with cold deserts of Himachal Pradesh in terms of faunal assemblages. However, being contiguous with the Tibetan plateau a few species such as Tibetan argali, Tibetan Wild Ass and Tibetan woolly hare are seen occasionally in the region. It is also seen that Himalayan musk deer goes very deep inside the Girthi, Gori and Dhauli valleys.

2.4 Sikkim Plateau

Sikkim plateau is one of the smallest biogeographic provinces of India having geographical coverage of about 400 $km^{2.}$ This plateau is quite picturesque located at

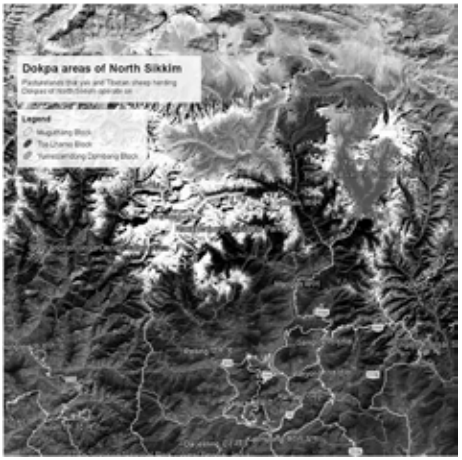

Fig 4. Map showing Tso Lhamo and adjacent blocks in north Sikkim

around 4500m asl. Adjacent to Tso Lhamu there are two moist valleys viz., Muguthang and Yumesamdong (Fig 4). Tso Lhamu is characterized by presence of extensive sedge meadows, scrub vegetation and morainic slopes all around. There are over 65 small glacial lakes largest among them being Gurudongmar that gives rise to river Teesta. Besides, there is a pre-historic brackish water lake called Gyamtshona. Rangelands of Tso Lhamo and adjacent valleys harbour a number of domestic livestock especially yak, sheep and horses. In addition, it is home to a number of highly threatened wild mammals including endangered snow leopard, Pallas's cat, Tibetan wolf, Tibetan sand fox and ungulates viz., eastern sub-species of kiang (*Equus kiang oligodon*), Tibetan gazelle, Tibetan argali, blue sheep and burrowing mammals such as Himalayan marmot and pikas. Historically, this plateau also had Tibetan antelope (Chanchani et al., 2011). In addition, the plateau is rich in avifauna including some of the migratory ducks.

The alpine vegetation of Tso Lhamu comprise dwarf scrub dominated by *Rhododendron ciliatum*, *Ephedra gerardiana, Myricaria prostrata,* and *Hippophae tibetana*; mixed herbaceous communities, and sedge meadows. Common, mat forming sedges include *Kobresia royleana*, *K. schoenoides* and *K. pygmaea*. The pastoral communities on Tso Lhamu i.e., Dokpas originally belong to the neighbouring Tibetan Autonomous Region of China, with a few from Sikkim who only started rearing yaks in the past three decades (Luxom et al., 2022).

3.0 Current trends in pastoral practices

3.1 Ladakh

There are three types of pastoral practices in Ladakh, viz., Nomadic and semi-nomadic pastoralism among Changpas of eastern plateau (Indian Changthang), nuclear transhumance in parts of Zanskar and sedentary (agro-pastoral) practices in lower Indus valley. The transhumance in the region is practised mostly by *Bakerwals* and *Chopans* (traditional herders hired by the Kashmiri livestock traders) in Drass and Surru valleys during May to August. In central Ladakh and Shakar – Chiktan Valleys livestock graze the rangelands for almost 10 months and are stall-fed for 2 about months while in Drass and Suru valleys livestock graze on upper mountain slopes for a period of 6 – 7 month only and for rest of the year they are stall-fed. In order to meet the fodder requirements the local communities maintain hay meadows and partly use agricultural residues for fodder requirement. At places the locals manage their land efficiently following agri-silvipastoral system. This area has also made a considerable progress in horticulture, besides growing poplar and willows trees as a source of timber, fuelwood and other household items.

The Changpas raise yaks, sheep, goats and horses and sustainably harvest livestock products, paying a portion of annual yield to respective Gompas as tax, consuming a portion

and bartering yet another portion along with salt to obtain grain and other necessities such as food grains and tea. Of the various livestock species, the *Changra* or *Pashmina* goats are most prized as they yield the most valuable wool. Changpas have been managing the livestock grazing by dividing the rangelands into winter and summer pastures. They use these pastures following an age-old rotational grazing system through spatio-temporal shifts of grazing pressure.

The pastoral and agro-pastoral communities of Ladakh have, till recently, ensured sustainable use of pastures following self-imposed rotational grazing practices and allocation of grazing areas among herders. Each pastoral group democratically elects a head or Goba (Changthang and other parts of Leh) or Moqdam or Namberdar (Zanskar, Suru and Drass Valleys) for a period of three years who takes decision on date of migration, use of water, arrival and departure dates of migration, duration of stay in each pasture and other uses such as collecting traditional taxes, fines and fixing conflicting issues related to agriculture and pastoral systems. The election of Goba in Changthang is still traditional where a dice is thrown to choose the headman. Ones a Goba is elected a small group of men or an advisory committee is selected to assist the Goba (usually a male herder). In lower valleys and Zanskar, the villagers have their own system of pasture allocation and rotation. For example, in Zanskar, yaks, Dzos and Dzomos (yak-cow hybrids) are taken to alpine pastures (doksas) at the beginning July and returned to villages during late October. These herders (dokspas)

Table 1: Area statistics and livestock population of Ladakh as per Livestock Census of 2020-21 (Source: Statistical Handbooks of Leh and Kargil Districts, LAHDC, Ladakh).

SN	Particulars	Leh	Kargil
1	Geographical Area	45000 km^2	14036 km^2
2	Total population	133487	140802
3	Rural Population	87816	124464
4	Area under agriculture	105.42 km^2	114.54 km^2
5	Sheep population	98611	145734
6	Goats	198787*	135382
7	Cattle	35839	48362
8	Dzo / Dzomos	34174	16607
9	Yaks	20302	6300
10	Equids	4420	5570
11	Camels	298	-
12	Rabbits	80	-
13	Poultry	20829	65439

* Pashmina goats 2,22,682 as per 2020-21 Census

follow a fixed pattern of migration. However, their departure from village is set by the Moqdam. The dokspa herders have access to their defined grazing areas and have exclusive rights over them. They own around 10-15 yaks, apart from it they also take yaks of other villagers along with them. In return they can keep 1/3rd of the milk products such as ghee and dried cheese (*Chhurpe*) for them. Except for this, however, no monetary arrangement exists as payment for yak rearing. With the passage of time and with the degradation of pastures these community institutions have not been able to take part in active management of pastures, preparation of zonation plans and schedule for rotational grazing.

Present estimate of livestock in Ladakh is 6,92,396 (2021 Livestock Census). The data on livestock population of Ladakh reveals that on an average each rural household owns 15 – 20 livestock. Major species reared include goats, sheep, yak, yak – cow hybrids (Dzos and Dzomos), horses, mules and donkeys. A general statistics on livestock in Leh and Kargil districts are shown in the following table (**Tabl**

The number of livestock in Ladakh have been fluctuating. While extremely harsh winters in Changthang had caused mass mortality of livestock during past, there are other socio-economic reasons in other areas. For example, in Kargil district there has been drastic decline in livestock after Indo-Pak conflict in 1999 (**Fig 5**; Raza, 2024).

3.2 Himachal Pradesh

The local communities in the trans-Himalayan ranges of Himachal are largely agro-pastoral and have grazing rights in adjacent rangelands. In some areas they lease pastures to the trans-humans pastoralists from the adjacent regions such as Lower Kinnaur, Chamba and Bharmour. The locals own goats, sheep, yaks, cows, dzo and dzomo (crossbred of yak and cow), horses and donkeys. According to the Department of Livestock Husbandry, Lahaul and Spiti currently there are about 65,000 heads of resident livestock in the district and almost equal number may be coming for summer grazing from the adjacent districts. According to a recent study (Singh et al., 2020) there has been a decline in the population of sheep and goats largely due to shortage of human resource and shortage of fodder during winter season and availability of other livelihood options such as homestay tourism and cultivation of cash crops. The locals cultivate a considerable amount of fodder in agricultural fields

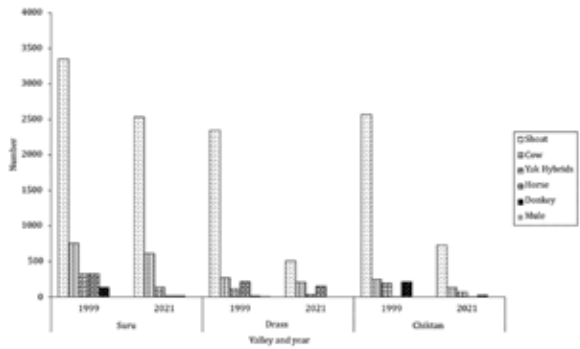

Figure 5. Decline in livestock populations in three valleys of Kargil before and after Kargil War (Source, Raza, 2024)

including wheat to stall feed livestock during winter.

As elsewhere in the Himalayan region, there is a greater emphasis on the education of younger generation and they get less and less exposure to traditional knowledge pertaining to livestock rearing. In fact, in much of these districts livestock husbandry is now dependent on immigrant labour from Punjab and Nepal.

3.3 Uttarakhand

The trans-Himalayan valleys in Uttarakhand are used as summer grazing grounds by a large number of local and migratory pastoral communities from the lower districts of the state and partly from Himachal Pradesh. Prior to 1962 the local communities (*Bhotiyas*) in these valleys had a considerable transhumance pastoralism as well as trade with Tibet. The communities (Jads, Marchha, Tolchha, Shauka and Rangs) had yaks, sheep and goats as a means to transport the goods across the borders. The Rangs in Darma and Byans valleys also had free trade and grazing rights in Nepal (Pandey et al., 2016). Unlike Ladakh and Spiti the local communities in the alpine villages of Uttarakhand trans-Himalaya migrate to their winter settlements at lower altitudes and winters are free from livestock grazing. As of now, Nilang Valley falls within Gangotri National Park and there is no permanment village. However, approximately 10 – 15,000 sheep and goats belonging to Jadhs of Uttarkashi (original inhabitants of Nilang), and Kinnaur continue to visit this valley during summer.

Upper Alaknada catchment and Saraswati Valley, Niti and Girthi valley (northern areas of Nanda Devi BR) are visited by over 20,000 sheep and goats belonging to shepherds of Chamoli district. Though, the Animal Husbandry data of Uttarakhand indicates that the sheep and goat populations in the state are about 2.84 and 13.71 lakhs respectively, the ratio of sheep and goats visiting the alpine arid pastures according to an estimate is 65 and 35 % respectively. The sheep are reared for wool as well as meat, while goats are an important source of meat and, to a lesser extent, for their rough wool (the long outer body hair) used to make rope and handicrafts. Horses and mules form 1% and 0.2% of the migratory livestock population, respectively, and are used primarily for carrying loads. Each herder group keeps three to four dogs for the safety of livestock, protection from wild animals such as snow leopard, common leopard, red fox and free ranging dogs. The local community (through Van Panchayat) levies a tax of Rs 5 to 6 per head of livestock for grazing per season and Rs. 70/- per equid.

The Upper Johar, Darma and Byans valleys have also seen a major transformation during past 4-5 decades as only 10 – 15% families visit their summer settlements and very few of them own sheep and goats. These valleys, however receive about 15-20000 sheep and goats belonging to shepherds of lower altitudes in the district and a few Gaddi shepherds of Himachal Pradesh under the similar arrangements as in Niti Valley.

3.4 Sikkim

According to the Animal Husbandry records presently there are 41 households of Dokpas in north Sikkim having about 3400 heads of livestock which use the pastures in three blocks, viz., Muguthang (10 households about 1000 yaks), Tso Lhamo (13 households, 12 yaks and 200 sheep) and Yumesamdong (18 households and about 1000 yaks). The Muguthang Dokpas take their yaks to Naku valley during winter. Interestingly, the Tso Lhamo Dokpas move towards higher plateau during peak winter as the higher plateau receive less snowfall. The yak in the area is of Tibetan breed (*Bos*

grunniens) and the sheep is also of Tibetan breed (*Ovis aries*), locally known as bherlung. In addition to these, Sikkim plateau is grazed by about 2000 heads of livestock, largely yaks, belonging to the people of Lachen and Lachung valleys. However, as in other parts of Western Himalaya, the number of livestock in Tso Lhamo area especially sheep has declined drastically from about 2000 to 200 during last 20-25 years. Several Dokpa families have moved out of Tso Lhamu to Gangtok and lower parts of Sikkim. The plateau is permanently inhabited by security personnel (Indian Army) and visited annually by about 17 lakh tourists (India Tourism Statistics report 2023).

4.0 Major Issues and Challenges

4.1 Rapid changes in pastoral practices and decline in traditional knowledge system

Traditional herding practices and livestock ownership patterns among the pastoral communities have been changing rapidly in the region (Dolphus 2013, Angmo *et al.*, 2016, Pandey *et al.,* 2016), Informal interactions with the herders across the states reveal that the younger generation in all the sub-regions does not find pastoral way of living attractive enough. For example, many Changpa families from Changthang have given up pastoral practices and migrated to Leh. In Spiti and inner valleys of Uttarakhand the agro-pastoral communities prefer their children to study in cities and find white collar jobs rather than be shepherds or farmers. In Kashmir and other parts of Himachal Pradesh the rich herders often engage poorer shepherds to take care of their livestock. In a study in Nilang valley we found that the younger generations of Jads have forgotten more than 70% local names of plants in their pastures (*personal observation*).

Traditionally, the agro-pastoral and pastoral communities of Ladakh have sustainably managed crops, rangelands and livestock with agreed division of labour and exchange of commodities through barter system. These service exchange systems (viz., Lhangde, Bess, Bonglud, Raress and Baress) were well established. However, under the pressure of globalization, cash economy and changing climate, these communities are going through progressive socio-economic transformation with visible changes in cropping and animal husbandry practices. In the areas with easy market access, the local farmers have switched over to cultivation of cash crops such as green peas, potato and other off-season vegetables and abandoning the traditional crops. In the areas dominated by Buddhists, systems of primogeniture, monastic celibacy, and polygamy have prevented the fragmentation of land holdings and checked the growth of human population. Also, many pockets of Ladakh have witnessed outmigration of pastoral communities to urban and sub-urban centres. This has led to loss of traditional ecological knowledge on pastoral practices among younger generation and disintegration of age old symbiosis between the agro-pastoral and pastoral systems (Singh *et al.,* 2020).

4.2 Degradation and shrinkage of rangelands

Studies have shown that several alpine arid rangelands especially those having sedentary livestock grazing round the year have degraded over the years leading to loss of primary productivity, shortage of forage and loss of species diversity (Tewari *et al.*, 2016, Raza 2024). Overstocking of livestock coupled with collection of shrubs and dung for fuel, siltation of moist meadows due to soil erosion owing to road cutting, establishment of tourist camps on moist meadows and closer to water courses are the major causes of degradation. Excessive removal of fuel wood and conversion of scrub-steppe into desert steppe is one of the major issues in rangelands of Ladakh (Uniyal *et al.*,

2005). Some of the common shrubs in the rangelands of Ladakh e.g., *Caragana versicolor*, *Ephedra gerardiana*, *Lonicera spinosa*, *Karscheninnikovia ceratoides*, *K. pungens*, species of *Artemisia* also play important ecological role besides their forage value. It is established that *Caragana versicolor* and *Krascheninnikovia pungens* serve as keystone species in these areas and help in stabilization of the slopes by checking soil erosion and serve as nurse crops for a number of palatable fodder species crucial for the survival of both domestic and wild ungulates. Removal of these shrubs lead to rapid degradation of rangelands in the form of reduction in primary productivity, loss of humus and nutrients and increased soil erosion. Besides brushwood, in many parts of Ladakh, high altitude rangelands are also subjected to illicit extraction of high value medicinal and aromatic plants. Digging of perennial herbs, especially rhizomatous and tuberous ones at extremely high altitude (sub-nival zones) lead to rapid depletion of thin surface soil and important microbial crust which is extremely important for further establishment of native vegetation. According to the herders symptoms of degradation in parts of Changthang include drying up of patches, infestation by insects and increase in abundance of unpalatable species such as Lantang (*Physochlaina praealta*) and Tserma (*Cirsium arvense*).

Being cold arid environment with very low primary productivity, herders of Ladakh have always faced fodder deficit. According to an estimate there is a fodder deficit of 69.44% in Ladakh region i.e., an availability of 1.43 lakh MT against a requirement of 4.68 lakh MT, calculated on dry matter basis (Department of Animal Husbandry, U.T. Govt of Ladakh). It is estimated that on an average there is 20-30% body weight loss in livestock during the lean season due to shortage of feed. Fresh estimates of fodder availability and requirement, and loss of body weight due to fodder scarcity in Lahaul and Spiti are not available.

In recent years rangelands of Spiti and Ladakh have become popular tourist destinations due to presence of charismatic species of wildlife such as snow leopard, and mesmerizing landscape. One of the reasons for such a boost in tourism is rapid development of infrastructure including road network. This exerts enormous pressure on the fragile landscapes and rangelands. In eastern Ladakh a large number of pastoral families have now resorted to homestays and there is a tendency to convert sedge meadows into new buildings for homestay leading to further degradation and shrinkage of rangelands.

4.3 Human-wildlife conflicts

Livestock depredation by wild carnivores is an emerging issue in rangelands of Ladakh and Spiti. Major species involved in livestock killing are snow leopard, brown bear and Tibetan wolf. Any loss to livestock results in a direct monetary loss to the herders particularly when snow leopard or wolves end up in mass killing. It has been observed that such conflicts are more in the degraded rangelands where wild prey for carnivores is very sparse or whenever the livestock is left in the pastures unattended. The Department of Wildlife Protection, with the help of a few conservation NGOs has been working closely with the local communities to support the predator proof corrals in a few parts of Ladakh e.g., Rangdum area of Surru Valley and Rong Valley near Hemis NP. In this context, community based livestock insurance schemes have proven to be very effective in speedy payment of compensation in case of depredation of livestock and thereby reducing the chances of retaliatory killing of carnivores. General trend of livestock depredation by wild carnivores in Kargil area is shown in Fig. 6.

unpredictable during recent years with

The herders in Eastern Ladakh (Changthang)

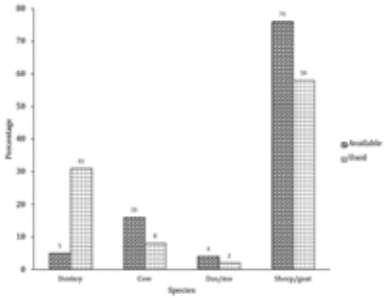

Fig. 6 % of Livestock population and proportions decimated by wild carnivores in Kargil during 2020 -2022 (Raza, 2024)

perceive that wild herbivores such as Tibetan wild ass and blue sheep deplete their winter pastures resulting in shortage of forage for domestic livestock. However, it is noteworthy that populations of both domestic as well as wild ungulates have been fluctuating in these rangelands since historical times depending upon the year to year variation in rangeland productivity and severity of winters and no scientific study has proven that wild ungulates with their low number will deplete the pastures. It is pointed out that overall population of wild ungulates in Changthang is one tenth of the population of domestic livestock. Hence, participatory restoration and monitoring of rangelands health along with response of wild and domestic ungulates would be desirable.

4.4 Climate Change and Depletion of Water Resources in the Rangelands

The Indian trans-Himalaya are disproportionately vulnerable to climate change. The region has experienced increased summer precipitation (rainfall) and increased average temperature. According to the herders the winter months have been more increasing incidences of extreme weather events. This has direct implications for forage production and quality of Pashmina wool. According to Changpas freezing temperatures and severe winds are essential for formation of fine quality of Pashmina. Thus warmer winters could affect the livelihoods of over 3,00,000 inhabitants of Ladakh and Kashmir.

High altitude marsh meadows are generally located in the Changthang plateau and also along margins of Indus river. They are important hotspots of biodiversity and play important role in shaping the hydrology and ecology of rangelands. The marsh meadows harbour many endemic and endangered species, including endangered black necked crane (*Grus nigricollis*). One of the reasons for depletion of marsh meadows is diversion of spring water to cultivable crops and to the tourist and other camps. It is seen that the the agro-pastoral villages along the upland valleys and downstream of snowfed streams subsist partly on agricultural production. The villages below 3500m asl also grow several fruit bearing trees such as apricot, plum, apple

and several species of willow (*Salix* spp.) and poplars (*Populus* spp. In general, villages get water for irrigating their lands from upstream areas mainly from the snow-fed streams and rivulets. The farmers often form water channels along contours to irrigate their fields. In many instances excessive diversion of water for agriculture leads to shortage of water supply to moist meadows and degradation of rangelands.

4.5 Lack of synergy among line agencies and enabling policy on rangelands

There has been inadequate convergence and coordination among the line agencies viz., Forest and Wildlife Management, Animal Husbandry, Tourism, Rural Development and Defence in several areas. As a result, various departments often work for cross purposes and landscape level conservation and development are distant dreams in the area. This leads to conflicts and decline of natural resources such as rangelands, water and other bioresources. Lack of dialogue and participatory processes also leads to alienation of herders and their participation in conservation programmes. Participatory planning process is widely recommended to achieve the Sustainable Development Goals and for mainstreaming biodiversity conservation and innovative livelihoods through effective convergence, knowledge improvement and improved micro-planning. Convergence of Line Agencies has also been amply stressed by several agencies.

5.0 Management Strategies

5.1 Eco-restoration of degraded pastures

Depending upon the severity of degradation, grazing regime, livestock density and topography, two approaches of restoration can be taken, i.e., passive and active restoration. Passive restoration can be piloted in the pastures where only plant cover has been depleted and soil is intact. Re-establishment of natural vegetation in such pastures is relatively easy through participatory approaches, led by the pastoral community. This requires minimizing excessive biotic pressure and temporary (4-5 years) exclusion of livestock from the pastures. Several successful examples of passive restoration are available from the Indian Trans-Himalaya. For example, community driven restoration programme in Niti Valley within Nanda Devi Biosphere Reserve, Uttarakhand. Here the Community Forestry Users Group (*Van Panchayat*) of Niti decided to restore a hill slope by providing it complete protection. The hill slope is protected from livestock grazing and collection of any non-timber forest produce during the growing season. Only towards the end of the growing season the villagers set aside 2-3 days for collection of fodder. All other non-timber forest products, especially high value medicinal plants are collected sustainably and shared equally among the villagers and enough growing stock is left in the mountain slope through self-imposed regulatory mechanism.

Active restoration would be required at the heavily degraded sites characterized by totally depleted vegetation cover and signs of sheet and gulley erosion. First step in active restoration is plugging the channels and gullies created due to excessive weathering followed by plantation or seeding with native species. Pre-planning and creation of nurseries for plantation would be required. Best sources of plant propagules and rhizome are the similar sites (in terms of altitude and topography) where fresh roads are being cut. This requires greater amount of time, money and efforts.

It is to be noted that mountain slopes with low vegetation cover and naturally eroded or exposed topography which give the appearance of 'barren land' need not be classified as degraded rangelands. Undoubtedly areas recently degraded due to diversion of water or development of physical infrastructure

and encroachment of critical wetlands will require rehabilitation and restoration but recovery of such sites will require much longer period as compared to temperate or sub-tropical grasslands. In all the areas especially Changthang plateau and Tso Lhamo conversion of sedge meadows into human habitation should be restricted. Use of peatland for construction of temporary shelters especially in Tso Lhamo will lead to loss of meadows and erosion. Livestock and Wildlife Departments need to jointly develop restoration strategies and implement in a time bound manner.

5.2 Strengthening community institutions in co-management of rangelands

One of the effective ways to maintain the health of rangeland ecosystems is strengthening the community based organizations such as Van Panchayat (Uttarakhand), Dzumsa (North Sikkim), Village Panchayat (Kinnaur and Spiti) and Herders' association and encouraging them to implement simple conservation and co-management plans. It is desirable that communities are encouraged to follow the traditional herding practices and self regulated resource extraction. One example of self regulated herding practise comes from Tsokar basin in Changthang where herders maintain winter pastures in healthy state. To reduce undue pressure on winter pastures, traditional migration patterns need to be revived and herders should be encouraged to extend stays at summer pastures. Traditional arrangements such as the 'tsabkak' system should be revived to protect pastures and herders should be empowered to follow adaptive management practices so as to reduce conflicts among them and with line agencies especially forest and wildlife.

The rangelands which are rich in wildlife, high value medicinal plants and great potential to become good destination for cultural or nature based tourism will especially require innovative approaches to manage rangelands for multiple functions so as to realize potential benefits. This will need hand holding and support from the tourism / wildlife department. It is possible to set aside a parcel of rangeland free from livestock grazing so as to avoid competition with wild herbivores and also ensure soil and moisture conservation. One example of participatory conservation and livestock management approach comes from Kibber Wildlife Sanctuary in Spiti (H.P.) where the villagers have set up a grazing free reserve. In such reserve, wildlife has been thriving without competing with the domestic livestock and anthropogenic pressures and such areas are earmarked grazing free. According to the Snow Leopard Trust (https://www.snowleopard.org/good-news-for-snow-leopards-in-india/), grazing free reserve are created by herding communities in snow leopard habitat. Part of the grazing area belonging to the village council is protected from livestock and other forms of resources use to enable the recovery of snow leopards and their prey.

Within trans-Himalayan valleys of Uttarakhand, especially Niti, Johar, Darma and Byans valleys there is a system of Van Panchayat for the control of livestock grazing and other resource use. Despite several limitations, this system has worked well so far and need to revamping.

5.3 Development of sustainable energy for the herders

In most of the trans-Himalayan rangelands the herders use brushwood as source of fuel for cooking and heating the houses. According to a study conducted by WII during 2009-10, in Changthang plateau each herder family consumes around 600 kg of brush wood during winter (October to April) and around 400 kg/month during summer season. It was also observed that proportion of fuel wood as well as dung was equal both in summer and winter (Fig 7). The other

sources of energy in the survey area are Kerosene oil and the light petroleum gas (LPG). Lahaul and Spiti and Kinnaur districts of Himachal Pradesh has a system of supplying subsidized fuelwood, smokeless woodstoves, solar cookers, etc during winter. However, such system has not well developed in high altitude areas of Uttarakhand and Sikkim. In recent years the UT of Ladakh has been proactively meeting the energy demand of the agro-pastoral and pastoral communities at a subsidized rate. However, there is a considerable use of fuel wood and dung from the pastures for cooking and heating. Thus, there is an urgent need to provide alternate source of energy to the herders so as to minimize the use of brushwood from the rangelands.

5.4 Convergence and Capacity Building of Line Departments

So far the rangelands have been treated as 'common property resource' throughout Indian Himalayan region. Though several line agencies such as Department of Animal Husbandry, Sheep Husbandry, Rural Development, Forests and Wildlife are directly or indirectly concerned with the health of rangelands, there is hardly any convergence among them. In the absence of any professional course on 'Rangeland Management' most of the frontline or middle level staff are unsure of ecological basis of managing the pastures, nutritional ecology or basic knowledge on high value fodder resources of Ladakh. It is therefore, high time that the frontline staff of Sheep / Animal Husbandry as well as Forest/Wildlife Departments be encouraged to find the formal courses on Rangeland Management. Since, there is hardly any state or national institution in India that imparts training on Rangeland Management, it may be prudent to initiate such a course on this subject in forestry training institutions. The officers trained in Rangeland Management should be assigned the task of monitoring rangeland health, eco-restoration and fodder development in and around agro-pastoral villages, wildlife protected areas, etc.

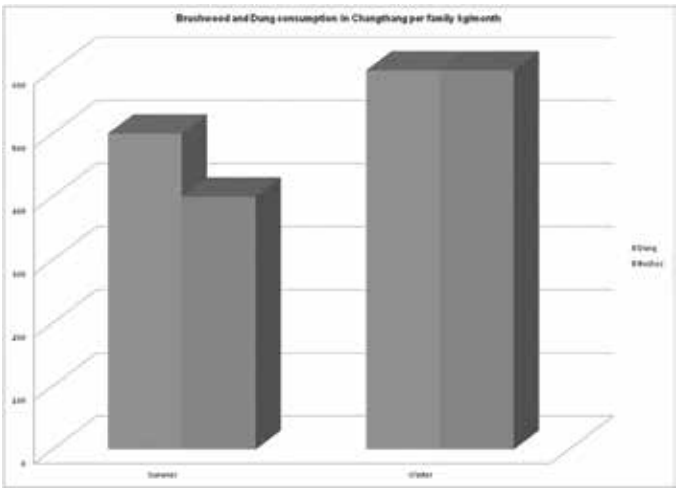

Fig 7: Proportion of fuelwood and dung used for cooking and heating in Changthang (WII Unpublished).

5.5 Need for Integrated Rangeland Management and Conservation Planning

The alpine arid rangelands in each of the

sub-regions need to be managed for multiple functions in a holistic manner. Sectoral and top-down approach of management often leads to stress on ecosystem and affects health of rangelands and flow of ecosystem services. The integrated plan must take into consideration basic assets such as cryosphere, local biodiversity, ecosystem health on one hand and climate change adaptation, human well-being and livelihoods of pastoral communities on the other. The landscape level conservation and development planning would also require identification of areas of high conservation value (e.g., Sahana *et al.,* 2023). A broad strategic framework for integrated management of rangeland resources and pastoral production for the trans-Himalayan rangelands is suggested in Fig 8. Such a framework calls for innovation, close integration and participation at all levels connecting the management with the goals of sustainable development and other national targets.

Recently, the Union Territory Administration of Ladakh has drafted a policy for Rangeland and Fodder Development based on a wide consultation. However, this policy awaits notification and implementation. Other states in the Indian Trans-Himalaya also need to come up with similar policy papers.

6. Way forward

Based on the foregoing discussion it emerges that traditional pastoral practices in the Trans-Himalaya are on rapid decline and in future there would be more of a sedentary grazing in places such as Changthang. Outmigration of youth would mean that traditional knowledge related to sustainable pastoralism would be forgotten rapidly. As of now there is no comprehensive assessment of ecosystem services from Trans-Himalayan rangelands. Such an exercise will greatly help in formulating the appropriate mechanisms of payment for ecosystem services and rangeland

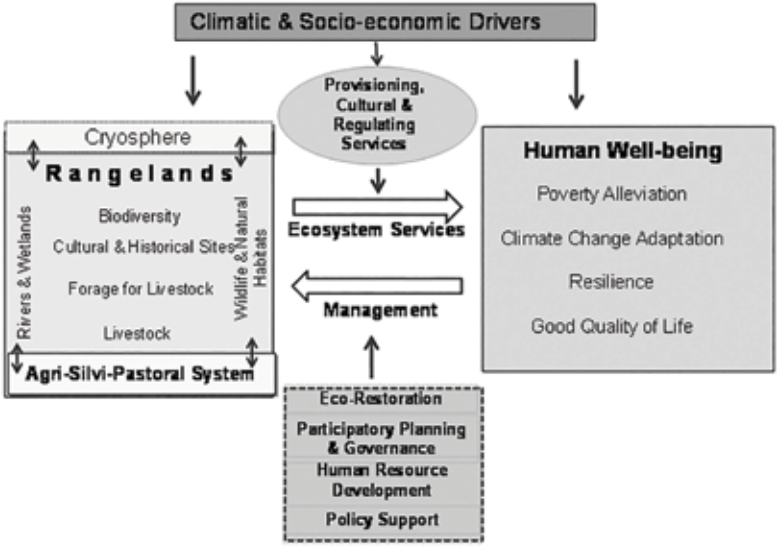

Fig 8: A Strategic Framework for Integrated Management of Rangeland Resources and Pastoral Production in Indian Trans-Himalaya

policy for the region. In many parts of Trans-Himalaya there is a need to establish community fodder banks cum grazing free reserves. Such banks would also serve as reservoir for propagules (seeds and rhizomes) of high value medicinal and aromatic plants, fodder species as demonstration plots.

There is a need to initiate a comprehensive Rangeland Monitoring Programme for different parts of Trans-Himalaya. This programme should include monitoring of weather parameters, rangeland productivity, recovery of restoration sites, seasonal use of rangelands by wildlife, changes in forage species composition and green cover due to changing climate, Carbon budgeting, etc. This programme can be dovetailed with programmes such as 'Long Term Ecological Observation network and Carbon Neutral Ladakh of Ministry of Environment, Forest and Climate Change (MoEF&CC 2020), ongoing programmes of national and state level institutions / University Departments. There is a need to develop a Rangeland Management Training Programme for the frontline staff of Forest / Wildlife Department. Conventional Course on Forest Management at forestry training institutes.

Lastly, the national institutions such as NIHE should undertake more inter-disciplinary studies integrating ecological and social studies in the context of Indian Trans-Himalaya and dive deeper into sub-regional specificities so that the existing frameworks can be refined and verified for nature-based solutions in these rangelands.

References

Angmo K., Kanwar, M.S., Dar, R.A. & Rawat, G.S. (2016). Recent changes in yak herding practices in eastern Ladakh and implications for local livelihoods. Yak on the Move: Transboundary Challenges and Opportunities for Yak Raising in a Changing Hindu Kush Himalayan Region. International Centre for Integrated Mountain Development, Nepal, May 2016.

Anonymous (2011). Management Plan for the Upper Spiti Landscape including Kibber Wildlife Sanctuary. Himachal Pradesh Forest Department and Nature Conservation Foundation. 299 pp.

Chanchani, P., Rawat, G.S. & Goyal, S.P. (2011). Ecology and Conservation of Ungulates in Tso Lhamo, North Sikkim. In Arrawatia, M.L. and S. Tambe (Eds.) Biodiversity of Sikkim, Exploring and Conserving a Global Hotspot. Information and Public Relations Department, Govt. of Sikkim. Pp. 354- 365.

Dolphus, P. (2013). Transformation process in nomadic pastoralism in Ladakh, Himalaya. The Journal of the Association for Nepal and Himalayan Studies. Vol. 32 (1): 60 – 72.

Jodha, N.S. (1992) Mountain Perspective and Sustainability, a Framework for Development. In: Jodha, N.S., Banskota, M. and Partap, T., Eds., Sustainable Mountain Agriculture, Oxford & IBM Publishing Co Pvt. Ltd., New Delhi, 41-82.

Kumar, A., Adhikari, B.S. & Rawat, G.S. (2017). Biogeographic delineation of the Indian Trans-Himalaya: Need for revision. Current Science 113 (6): 1032-1033.

Luxom, N.M., Singh, R. & Sharma, R.K. (2022).

Pastoral practices, pressures, and human-wildlife relations in high altitude rangelands of eastern Himalaya: A case study of the Dokpa pastoralists ofNorth Sikkim. Pastoralism Research Policy and Practice • September 2022. DOI: 10.1186/s13570-022-00252-6

Mishra, C., Prins, H.H.T. & Wieren, van S.E. (2001). Overstocking in the trans-Himalayan rangelands of India. Environ. Conserv. 28, 279–283

MOEF&CC (2020). Carbon Neutral Development of Ladakh. The Administration of the Union Territory of Ladakh & the Ministry of Environment, Forest & Climate Change. 2013 Pp.

Murali, R., Lkhagvajav, P., Saeed, U., Kizi, V.A., Zhumbai-Uulu, K., Nawaz, M.A., Bhatnagar, Y.V., Sharma, K., & Mishra, C. (2017). Valuation of ecosystem services in snow leopard landscapes of Asia. Snow Leopard Trust, Nature Conservation Foundation, Snow Leopard Conservation Foundation, Snow Leopard Foundation Kyrgyzstan, and Snow Leopard Foundation Pakistan. Report Submitted to the Global Environment Facility (GEF) funded United Nations Development Program (UNDP) project on Transboundary Cooperation for Snow Leopard and Ecosystem Conservation.

Pandey, A., Pradhan, N. & Ghate, R. (2016). Withering of traditional institutions? An institutional analysis of the decline of migratory pastoralism in the rangelands of the Kailash Sacred Landscape, western Himalayas. Environmental Sociology. Dec. 2016. https://doi.org/10.1080/23251042.2016.1272179.

Rawat, G.S. (2007). Pastoral practices, wild animals and conservation status of alpine meadows in Western Himalaya. J. Bomb. Nat. Hist. Soc. 104 (1): 251-257.

Rawat, G.S. & Adhikari, B.S. (2005). Millennia of Grazing History in Eastern Ladakh, India, Reflected in Rangeland Vegetation. In Spehn, Eva, M. et al. (eds.) Land Use Change and Mountain Biodiversity. CRC Taylor & Francis. Pp. 199- 210.

Raza, P. (2024). Agro – pastoral practices and their impacts on wild mammals in Ladakh, Indian Trans – Himalaya. Ph. D. Thesis (Unpublished). Wildlife Institute of India and Saurashtra University, Rajkot.

Rodgers, W.A. & Panwar, H.S. (1988). A biogeography based protected area planning for India. Vols. 1 & 2. Wildlife Institute of India, Dehradun.

Sahana, M. Sajid Sultan, M., Areendran, G., Ghoshal, A., Sivadas, A. Raj, K., & Parameshwaran, S. (2023. Assessing high conservation value areas for rare, endemic and threatened (RET) species: A study in high altitude Changthang landscape of India. Journal for Nature Conservation. 73 (2023). 126406. 1-21 Pp.

Singh, R., Sharma, R.K., Babu, S. & Bhatnagar, Y.V. (2020). Traditional Ecological Knowledge andContemporary Changes in the Agropastoral System of Upper Spiti Landscape,Indian Trans-Himalayas. Research, Policy and Practice (2020) 10:15. https://doi.org/10.1186/s13570-020-00169-y.

Uniyal, S.K., Awasthi, A. & Rawat, G.S. (2005). Biomass availability and forage quality of Eurotia ceratoides Mey in rangelands of Changthang, Eastern Ladakh. Current Science 89 (1) 201-205.

G.B. Pant Memorial Lectures

I
Dr. M.S. Swaminathan, Director, CRSARD, Madras - 1991

II
Dr. T.N. Khoshoo, Jawaharlal Nehru Fellow, TERI, New Delhi – 1992

III
Mr. V. Rajagopalan, Vice President, World Bank, Washington – 1993

IV
Prof. U.R. Rao, Member, Space Commission, New Delhi – 1994

V
Dr. S.Z. Qasim, Member, Planning Commission, New Delhi – 1995

VI
Prof. S.K. Joshi, Vikram Sarabhai Professor, JNCASR, Bangalore – 1996

VII
Prof. K.S. Valdiya, Bhatnagar Research Professor, JNCASR, Bangalore - 1997

VIII
Prof. V.K. Gaur, Distinguished Professor, IIA, Bangalore – 1998

IX
Prof. Y.H. Mohan Ram, INSA Senior Scientist, University of Delhi, New Delhi – 2000

X
Prof. J.S. Singh, Emeritus Professor, BHU, Varanasi – 2004

XI
Prof. Madhav Gadgil, Centre for Ecological Sciences, IISc, Bangalore – 2005

XII
Dr. S.S. Handa, Ex-Director, PRL (CSIR), Jammu – 2006

XIII
Dr. Lalji Singh, Director, CCMB, Hyderabad – 2007

XIV
Prof. Roddam Narasimha, Chairman, FMU, JNCASR, Bangalore – 2008

XV
Dr. R.S. Tolia, Chief Information Commissioner, Govt. of Uttarakhand, Dehradun – 2009

XVI
Prof. Raghavendra Gadagkar, CES & CCS, IISC, Bangalore – 2010

XVII
Prof. V. Nanjundiah, JNCASR, Bangalore – 2011

XVIII
Dr. Kirit S. Parikh, IRADe, New Delhi & Former Member Planning Commission – 2012

XIX
Prof. Jayanta Bandopadhyay, Former Prof. & Head, IIM, Calcutta – 2013

XX
Prof. T.S. Papola, Institute for Studies in Industrial Development, New Delhi - 2014

XXI
Dr. David Moulden, Director General, ICIMOD, Nepal - 2015

XXII
Dr. Vijay Raghavan, Secretary, Department of Biotechnology, New Delhi - 2016

XXIII
Prof. S.P. Singh, Former Vice-Chancellor, HNB Garhwal University, Uttarakhand - 2017

XXIV
Prof. P.S. Roy, Former Director, Indian Institute of Remote Sensing, Dehradun – 2018

XXV
Prof. Raman Sukumar, Professor of Ecology, Indian Institute of Science, Bangalore – 2019

XXVI
Prof. Tej Pratap, Vice Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar – 2020

XXVII
Prof. R. Raghavendra Rao, Chairman, Karnataka State Environmental Appraisal Committee - 2021

XXVIII
Dr. Navin Juyal, Formerly with Physical Research Laboratory
Department of Sapce, Ahamedabad, Gujrat - 2022

XXIX
Prof. Mohammed Latif Khan, Distinguished Senior Professor of Botany, Dr. Harisingh Gour Vishwavidyalaya (A Central University) Sagar, Madhya Pradesh

XXX
Prof. Zafar Ahmad Reshi, Distinguished Professor in the Department of Botany at the University of Kashmir, Srinagar