AGRO-PASTORAL PRACTICES AND THEIR IMPACTS ON WILD MAMMALS IN LADAKH, INDIAN TRANS-HIMALAYA

Thesis submitted for the award of the degree of

DOCTOR IN PHILOSOPHY

IN

WILDLIFE SCIENCE

By

MOHD RAZA

TO

Saurashtra University

Rajkot- 360005 (Gujarat)

Under the supervision of

Dr. G. S. RAWAT, Supervisor

Dr. TSEWANG NAMGAIL, Co-supervisor

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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DECLARATION

I, hereby, declare that the work conducted under this thesis titled "**Agro-pastoral practices and their impacts on wild mammals in Ladakh, Indian Trans-Himalaya**" is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Doctor of Philosophy in Wildlife Science** to the **Saurashtra University, Rajkot (Gujarat)**. This research work has been carried out under the guidance and supervision of Dr. G. S. Rawat (Former Scientist G/ Sr. Prof., Wildlife Institute of India, Dehradun), Dr. Tsewang Namgail (Senior Scientist, Snow Leopard Conservancy India Trust, Leh, Ladakh). The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

MOHD RAZA
Place: DEHRADUN

Date: 12-06-2024

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Wildlife Institute of India

CERTIFICATE

This is to certify that **Mr. MOHD RAZA** thesis, **"Agro-pastoral practices and their impacts on wild mammals in Ladakh, Indian Trans-Himalaya"** submitted for the degree of **Doctor of Philosophy in Wildlife Science at Saurashtra University, Rajkot, Gujarat**, embodies original research work carried under our guidance and supervision.

MR. MOHD RAZA has researched on this thesis for more than six terms under our supervision and guidance. The work presented in this thesis has not been submitted for any other degree. It meets all of the specifications stated forth in the ordinances of Saurashtra University in Rajkot, Gujarat, and the Wildlife Institute of India.

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I certify that the research work was appreciated by all who were present, and the comments made by the faculty and researchers have been appropriately included in the thesis.

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For the love of my Mother

Zehra Bi

Summary

Agro – pastoral production system is the primary source of local livelihood and land use in much of the Indian Trans- Himalaya. This land use system has evolved since millennia and sustained local economy as well as ecology. However, in many regions the traditional livestock husbandry practices are changing rapidly leading to changes in the status high altitude rangelands. Besides domestic livestock these rangelands harbour a rich array of flora and fauna. Arguably, the land use system and wildlife populations have coexisted, albeit with fluctuating trends. Sendenterization of livestock and intensive land use has led to degradation of pastures in many areas resulting in human-wildlife conflicts especially in the form of livestock depredation by the carnivores. Previous studies have reported that increasing livestock populations have affected the populations of several endangered species of mammals including smaller mammals e.g., long tailed marmot.

This study was conducted in Western Ladakh to address the status of current agro-pastoral practices and possible impacts on the wild mammals. Barley and wheat are primary crops whereas alfalfa and oats are cultivated as fodder crops. Sheep, goat and cow are major livestock types. Communities belong to *balti and purig* ethnicity. Elevation ranges from 2600 – 7000 m. Vegetation comprises wet meadow, steppe, riverine and scrub. Himalayan brown bear, Asiatic ibex, Ladakh urial, musk deer and long tailed marmot are major wild mammals.

Major objectives of the study were to study (i) the current status of agro-pastoral practices in the region, ii) vegetation structure and composition in the rangelands intensively used by domestic livestock, iii) habitat use and time budget wild mammals

especial long tailed marmots iv) livestock killing by large carnivores in western Ladakh.

Field work was conducted during 2017 -2020 in different seasons and valleys. In order to analyse the recent trends in agro-pastoral practices we used questionnaires and informal interviews with the local people ((519 respondents) in all the valley covering Chiktan (56), Suru (227), Drass (117), Shayok (39) and Gya – Meru (39). Data were collected on demography of the pastoral communities, livestock holding pattern, dependency on rangelands and drivers of changes in the region. Likewise, for objective 2) vegetation sampling was carried out in Drass Valley in varying level of livestock grazing intensity from June – August (2018 and 2019). We laid 245 quadrates, comprising 90 in low, 88 in medium and 67 in high grazing areas. We recorded number of species in each quadrat in addition to overall vegetation cover. We also recorded aspect, slope, elevation and landscape type for each quadrat laid in the area. Plants were identified in field using field guides and were authenticated by the supervisors. Habitat use data on marmot were collected from 51 colonies in two valleys whereas data on marmot behaviour was collected from Drass valley. Overall 88 households were interviewed in the valley. Households were randomly selected and data on number of livestock, livestock killed, season, time and place of occurrences were collected. Attitude of respondents with respect to carnivore was also assessed.

We observed declining trend in agriculture and livestock production practices in the region. Ten crop types are cultivated in the region. Barley is cultivated in all the valleys whereas oats is a new addition. Crops such as buckwheat, wheat, peas and lentils has been abandoned by many households. Likewise, livestock population and herd size has decreased in all valleys. Livestock population has decreased by 70% from 1999 -

2021 in Drass and Chiktan, whereas in Suru it has declined by 35% only. Likewise, dependency on rangelands in terms of resource collection has also decreased. Only 3% collect fuel wood, 38 % fodder plant, 52% food plants. Although livestock population has decreased most of households use rangelands for livestock grazing. Collection of fuel wood has decreased due to increased plantation of *Salix* spp. and *Populus* spp. trees in the region. Lack of human resources (53%) was the primary reason for its decline and fodder scarcity in decline of agro - pastoral practices in the region.

In terms of plant diversity, we recorded 125 species of vascular plants. Asteraceae was the dominant family (14%) whereas Companulaceae – Violaceae familes were less than 1%. Most of the plants were of herbaceous growth froms (115) and ferns less than 1%. Vegetation was predominantly hemicryptophytes (70%) and perennial, 98 species. Nineteen plant communities were found in the region. *Codonopsis-Psychrogeton – Trachydium* community was absent in highly grazed areas. Overall, species ranged from (3-14) species per plot. Higher number of species were recorded in low grazing area (14) compared to nine in high grazing areas ($F = 47.848$, $df = 244$, $P < 0.001$). Likewise, overall vegetation cover was 60% per plot. It varied significantly ($F = 18.009$, $df = 244$, $P < 0.001$), highest in low grazing areas (67%) and lowest in high grazing areas (48%). Vegetation cover and species richness also varied with respect to aspect, slope, and elevation landscape types and across livestock grazing intensity areas. Species richness and vegetation cover was also relatively lower in high grazing areas across all bio – physical attributes compared to low grazing areas. It decreased with respect to increase in slope and elevation in all areas. Vegetation cover and species number was relatively higher in north aspect.

Marmot population as well as group size was comparative similar in all grazing areas. It was 263; 5-22 in high, 275; 5-24 in medium and 249; 5-21 in low grazing areas. We observed increased in marmot population with elevation, with higher numbers recorded in mid elevations ranging from 3800 – 4200 m. Likewise they preferred intermediate slopes > 10 – 30 in across grazing areas. Overall, marmots were found using all aspect with maximum numbers observed in south (266) and north (207). But in high grazing area we observed higher number of marmot using north aspect (112) compared to (31) in low grazing areas. In low grazing areas marmot numbers in south slope was (119) compared to 68 in high grazing areas. Marmots were less observed in agri-fallow (4) landscape types and marshes (21). It was highest in meadows with ample rock cover. In terms of time budget we did not observe the presence livestock affecting its vigilance in the region. Although it increased with decrease in group size.

Total livestock loss was 7.44% of the total livestock population in the surveyed valley. Sheep and goats were the primary victims (58%) and cattle the least. Tibetan wolf killed most of livestock (33%) followed by bear (32%) and snow leopard 21%. Donkey was killed more than its relative abundance compared to other species. Besides bear killed donkey proportionately higher than it relative abundance. Other carnivores killed sheep and goats and were proportionately similar to their relative abundance. Bear and snow leopard killed livestock in corrals at night whereas wolf killed livestock in open areas only. Similarly, most of the livestock were killed near cliff (54%) and the least in areas away from cliffs. Maximum livestock were killed in spring (26%) and the least in winter (7%). Bear killed livestock the most in spring and autumn season, snow leopard and wolf never killed livestock in winter. Bear was the most

disliked due to livestock depredation, dismantling of roofs and compound walls, and raiding of ration stores.

The local communities perceive that there is a decline in traditional agro-pastoral practices in the study area during past 2-3 decades and an increase in sightings of wild mammals in the study area. Also, they perceive increase in population of Ibex and bear which are widely distributed in the region. We did not have enough sightings on mammal in the summer except for marmots in the region. Sighting on ibex were mostly in winter season. Therefore, impacts of low use of livestock on ibex populations could not be ascertained. We observed difference in vegetation cover and species richness across varying level of livestock intensity. Decrease in vegetation cover and species number, irrespective of all bio physical parameters was observed in high grazing areas. It signifies the impact of livestock grazing with implication on habitat use by mammals. Further, preference of northern aspect by marmots in high grazing areas compared to southern aspect signifies the decline in vegetation and species richness having adverse impact on habitat use by marmots. Aptly, it is also signifies the resilience in marmot behaviour, as their vigilance behaviour did not decreased with presence of livestock. Although, it decreased with decrease in group size and vice versa. Likes for ungulates and disliking on carnivores, particularly bear due to livestock depredation is a conservation challenge in the region. Pertinently, very less no of people receive compensation for losses incurred due to carnivores. . Livestock insurance scheme in the region are absent.

Overall, although livestock grazing has had an adverse impact on vegetation cover, species richness and marmot habitat use. These issue are present in localised areas

only. And in areas where livestock grazing is limited vegetation is relatively stable. This seek localised intervention to revive vegetation composition in the region by regulating livestock movement and numbers. Additionally, livestock depredation has to be addressed for conservation of endangered carnivore species in the region.

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Mohd Raza

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Chapter 1: Introduction

1.1. Background

Ladakh, located in the Indian Trans-Himalaya, represents one of the most spectacular cold desert ecosystem comprising alpine steppe (Hartmann, 2009) and snowcapped mountains forms about 5.6% of India's geographical area (Rodgers et al. 2000). This region is well recognized for its biological, geo-hydrological, socio-cultural and aesthetic values. Despite the cold arid and highly fragile environment, and very sparse vegetation cover (<5%), this region harbours a rich array of flora and fauna. A short summer season of about three months allows limited growth of vegetation that forms the sole basis of the high-altitude ecosystem. The region harbours about 1250 species of higher plants (Dvorský, 2018), 36 species of mammals, 8 species of herpetofauna and over 370 species of entomofauna, *albeit* the faunal communities are found in very low densities. Ladakh also falls under an important region for crop genetic resources, agro-forestry practices and home to several breeds of livestock including Pashmina goat, Purik sheep, yak, Bactrian camel, Zangskar and Chumur horses etc. Over 70% of the land mass falls under uncultivable rangelands that is only suitable for livestock production, wildlife conservation, growth and multiplication of high value medicinal and aromatic plants and nature based recreation. The rangelands also form critical habitat for several globally threatened species such as snow leopard (*Panthera uncia*), black necked crane (*Grus nigricollis*) and Eurasian Lynx (*Lynx lynx*), Tibetan argali (*ovis ammon*), Ladakh urial, Tibetan gazelle (*Procapra picticaudata*) and the Himalayan brown bear (*Ursus arctos isabellinis*). The people of Ladakh have inherited a rich culture, traditional knowledge and conservation ethos (Bhasin, 2005, 2011).

However, age old symbiosis between agro-pastoral and pastoral communities based on barter system have now transformed into cash economy (Fox et al., 1994; Rizvi, 1999; Nüsser et al., 2012) and the region is grappling with several ecological crises such as degradation and fragmentation of rangelands (Mishra et al., 2010) that impinges on pastoral production system (Namgail et al., 2007), local livelihoods, increasing human-wildlife conflicts (Bhatnagar et al., 2006; Namgail, et al., 2007), rapid loss of snow cover and changes in hydrology, soil erosion and depletion of alpine moist meadows which also serve as important carbon sink (Bagchi et al 2017). The rangelands form the backbone of agro pastoral livelihoods that has sustained the local communities for centuries (Adhikari & Rawat, 2006). In this thesis we attempt to analyze current trend in agro pastoral practices and rangelands dependency. Likewise we also assessed vegetation composition, habitat use by mammals particularly marmots, and group composition in ibex in varying levels fo grazing intensity. We also address local perception with respect to wildlife animal's particularity carnivores in the region.

1.2. Research rationale

Agro - pastoral practices despite its role in rural economy, culture and knowledge system is severely questioned for its negative impact on biodiversity, particularly on distribution and habitat use by wild mammals and vegetation dynamics of rangelands. Hardin, (2013) considers it as tragedy of commons by highlighting significant loss in biodiversity due to livestock overstocking in the commons or rangelands. Likewise, Prins (1992) questions harmony and co-existence between pastoral production system and wildlife conservation. He reveals overstocking and livestock population growth as factors for land degradation and probably the leading cause in pastoral extinction of

mammals in Africa. Further, Van De Koppel et al., 2000 in their study on grazing systems found catastrophic vegetation shift and soil degradation due to over grazing, leading to irreversible change in vegetation dynamics and soil compaction in many natural ecosystem. Such findings are marred with controversies and has led to conflict between agro pastoralists and conservationists. Nonetheless, Olff and Ritchie (1998) argues that effect of livestock on plant dynamics needs to be reassessed and highlights although livestock affect plant communities their impact on vis a viz plant diversity varies across environmental gradient and precipitation regimes. They conclude that incorporating such gradients would be helpful to understand the magnitude and direction of livestock grazing on plant dynamics and resolve controversies regarding impact of agro pastoral practices on rangelands particularly distribution and abundance of mammals that arises from comparing individual studies. Likewise, Ellis & Galvin (1994) highlights the impact of climate and rainfall variation on vegetation dynamics in rangeland and use by mammals. Their study identifies intercontinental areas where eco – climatic zone can be developed for economic development without losing agro pastoral practices and values. Pertinently, Christiansson et al., 1991 in their study on agro pastoral communities and conservation in Uganda, Tanzania argues that, although rangelands in Tanzania are severely facing environmental degradation; dwindling status of fuel wood, water and soil erosion, the real cause of rangeland degradation by agro pastoral lifestyle has to be established to avoid conflicts with communities. Likewise, Newmark, et al., (1994) propose designing integrated conservation policies that keep into account aspiration of communities, their historical use of protected area resources, issues of land tenure. They highlights understanding the nature and current cause of conflicts between people and protected areas for conservation of wild animal.

Moreover, Carter & Linnell (2016) emphasises on integrated studies on broad range of species to identify factors to reconcile debates about wildlife conservation and shared landscapes to advance broader discourse in conservation. Likewise, Scherr & McNeely (2008) highlights the significance of eco – agriculture areas in sustaining biodiversity globally. Furthermore, most studies emphasises on importance of agro pastoral practices and recognises the direct dependency of human on such practices for food, livelihood, and survival and advocate for integrated studies to understand of such practices on wild animals (Acevedo-Whitehouse & Duffus, 2009; Cole And Peter, 1996; de Groot & Ramakrishnan, 2005; Lambin & Meyfroidt, 2011; Millennium Ecosystem Assessment, 2005).

In the context of Ladakh, most of the people are subsistence agro pastoralists and are dependent on rangelands for sustaining this dynamic system. Additionally, communities in the east are pastoralists while in the west, migratory herders such as Bakerwals and Chopan tribes of J &K use the rangelands is summers. They stay in Drass and Suru valleys for a period of 3-6 months. However, this traditional system faces significant challenges due to various socio – economic, geo – political and environmental factors (Yamaguchi et al., 2016). Such factors has led to abandonment of agro pastoral practices in most of the villages in the region (Nüsser et al., 2012), whereas in east and the west due to significance of livestock economy and political interest in preserving in such culture has led to increase in livestock population (Namgail et al., 2010). Pertinently, armed conflict has had far reaching impact on traditional agro pastoral practices of communities inhabiting these regions along international borders (Dollfus, 2013). It is particularly evident in Drass valley, western

Ladakh. Likewise, these conflicts has disrupted livelihood securities in the region by causing displacement, restriction on access to pasturelands, changing agriculture and pastoral lifestyle, and inducing socio – economic transformation in the region. Moreover, co-existence of livestock and wildlife in the rangelands present additional challenge to the pastoral communities, including human wildlife conflict, livestock depredation by carnivores and perception of wild herbivores out competing livestock in forage use (Bhatnagar et al., 2006). On the other hand, their existence and increase in livestock population are challenged by wildlife conservationists on account negative effect of grazing on vegetation dynamics (Mishra et al., 2002), habitat loss (Bhatnagar, 2006) and displacement of mammals (Poudel et al., 2016). They suggest restricting livestock population and free areas for wildlife conservation. However these arguments are countered by (Saberwal, 1996a, 1996b; Sabharwal, 2016). They argue that there is a critical lack of insight into the political and historical mechanisms that lie within the dynamic interaction between resource access and socio- economic inequalities. Pertinently, Rawat and Adhikari, (2006) states that although livestock grazing has been in practice in the Trans – Himalaya since millennial the status of rangelands is good and stable. Nonetheless, such issues and divergent perspectives on land use, resource management and conservation priorities gives rise to conflict between communities and conservationists in the region thus jeopardising survival of species of prime conservation importance such as Snow leopard, Himalayan brown bear, wolf and addition to species of primary importance in maintaining rangeland health such as the long tailed marmot. Furthermore, we observed research gap in the understanding of impact of local agro – pastoral practices on wild mammals in Ladakh. Most of the research cited above despite being significant in their approach in

understanding of agro – pastoral practices and their impact on wild mammals lack an interdisciplinary approach in dealing the question of rangeland degradation, particularly in the context of transformation process in agro – pastoral practices in the region. Therefore to address this gap we undertook this study with the following objectives:-

1. To study historical and current trends in agro-pastoral practices and their impact on high-altitude rangelands in Ladakh.

In this objective, we addressed past and the recent trends in agro pastoral practices. This we did to understand current status of dependency of communities on rangelands. This study highlights factors leading to transformation processes in agro pastoral practices, particularly armed conflict. Additionally we address weather these transformation are positive for wildlife conservation and rangelands health or not.

2. To assess the impact of agro-pastoral practices viz livestock composition on plant communities and consequent effects on mammalian herbivores.

In this objective we address the question of the impact of livestock grazing on vegetation composition in alpine rangelands. Further, we try to understand weather impact of livestock grazing on vegetation composition occurs at a localised or regional scale. Additionally, we assess how livestock grazing influences wild herbivores distribution particularly, long tailed marmots.

3. Determine habitat use by wild mammals across gradients of anthropogenic pressure especially abundance of domestic livestock.

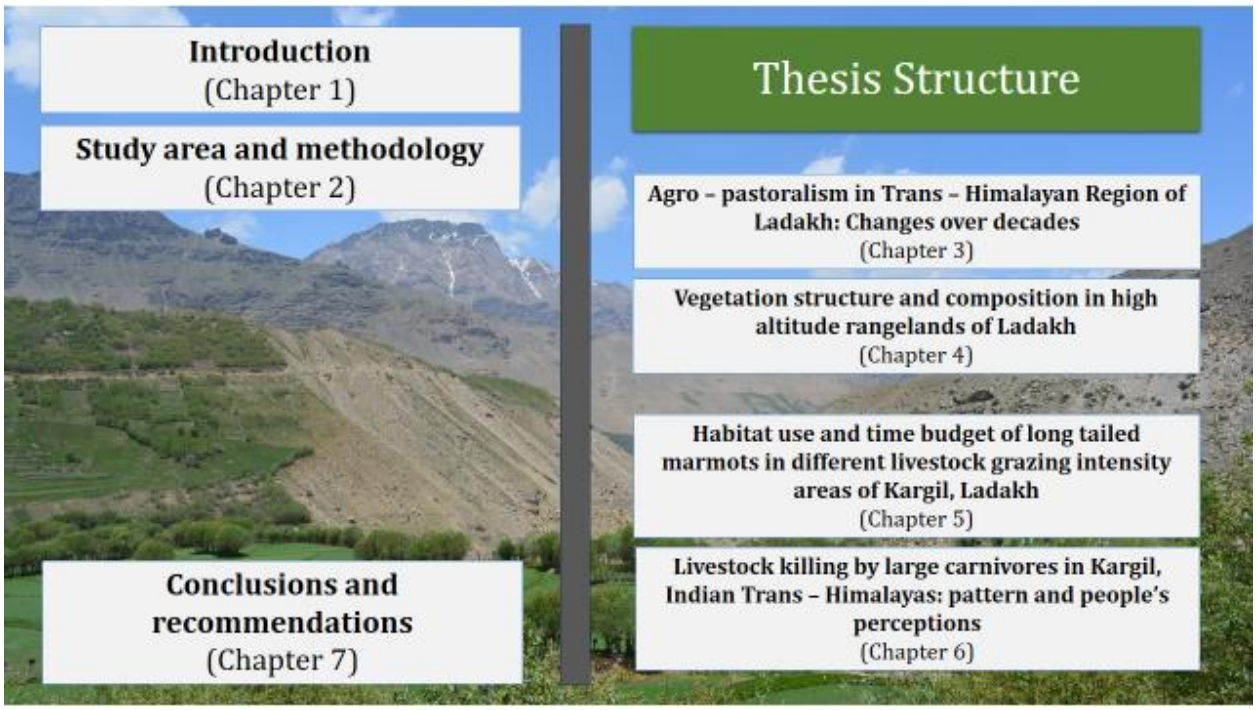
In this objective we addresses how habitat use by wild mammal particularly marmots, varies across gradient of agro-pastoral practice and pressure. Besides, in this objective we also addresses, abiotic factors governing habitat use by marmots. Further, we seek

answer to the question of displacement of wild mammals in varying degree of grazing intensity.

4. To examine spatio-temporal patterns of human wildlife conflict in terms of livestock depredation and crop damage

In this objective addresses the extent of livestock depredation and crop damage by carnivores and its spatio – temporal variation. Further, we seek answer as to why conflict between pastoralist and conservationists occurs in the Trans Himalayan rangeland. We also, addresses attitude of locals towards wild mammals in the valley to address concerns of the communities to develop conservation action plans in the region.

1.3. Thesis structure



Chapter 2: Study area and field methods

2.1. Study area

2.1.1. An overview

Ladakh (U.T.) in North India represents a landscape fragile both in terms of its environmental condition and geo strategic location (Image 2.1). Lying in the rain shadow of the Himalayan range (Rodgers et al. 2000) Ladakh is bounded by the Tibetan plateau in the east and Hindukush in the west, and Karakorum in the north and Great Himalayan range in its south. Besides two mountain ranges Zanskar and Ladakh runs parallel in east to west direction collectively forming Ladakh Trans Himalayas. Besides terrain in eastern Ladakh is considerably flat and undulating relatively than areas in western and southern parts of Ladakh where terrain is highly rugged and valleys narrow. Elevation ranges from 2700 m at Kharul, Kargil near Line of Control to peaks above 7000 m in Zanskar and Karakoram ranges. It shares international boundaries with Pakistan in its west and with China in the east. Within India it is bounded by the state of Himachal Pradesh (HP) and Union Territory of Jammu and Kashmir (J&K) in the south and south west respectively.

Administratively, the Union Territory (UT) of Ladakh comprises two districts; Kargil and Leh spread over approximately 14036 KM^2 and 82665 KM^2 (including 38000 KM^2 under Chinese occupation). Further for the ease of administration, Kargil is divided into 15 blocks (127 villages) and Leh into 16 blocks (113 villages). Human population in Ladakh is 2,74,289 individuals with a population density of 3 individuals KM^2. Kargil has a population of 1,40,802 individuals whereas Leh has a population of 1,33,487 individuals (Anon ,2020; Anon, 2018). Majority of the inhabitants in Kargil

are Muslims whereas inhabitants in Leh are Buddhists. Apart from these groups Ladakh is inhabited by Sikhs, Christians and Hindus. Moreover, eight ethnic groups are identified in the region namely; *Bot, Mon, Beda, Garra, Brokpa, Balti, Changpa* and *Purigpa*. Most of the ethnic groups are agro – pastoralists except the *Changpa's* who practice nomadic pastoralism.

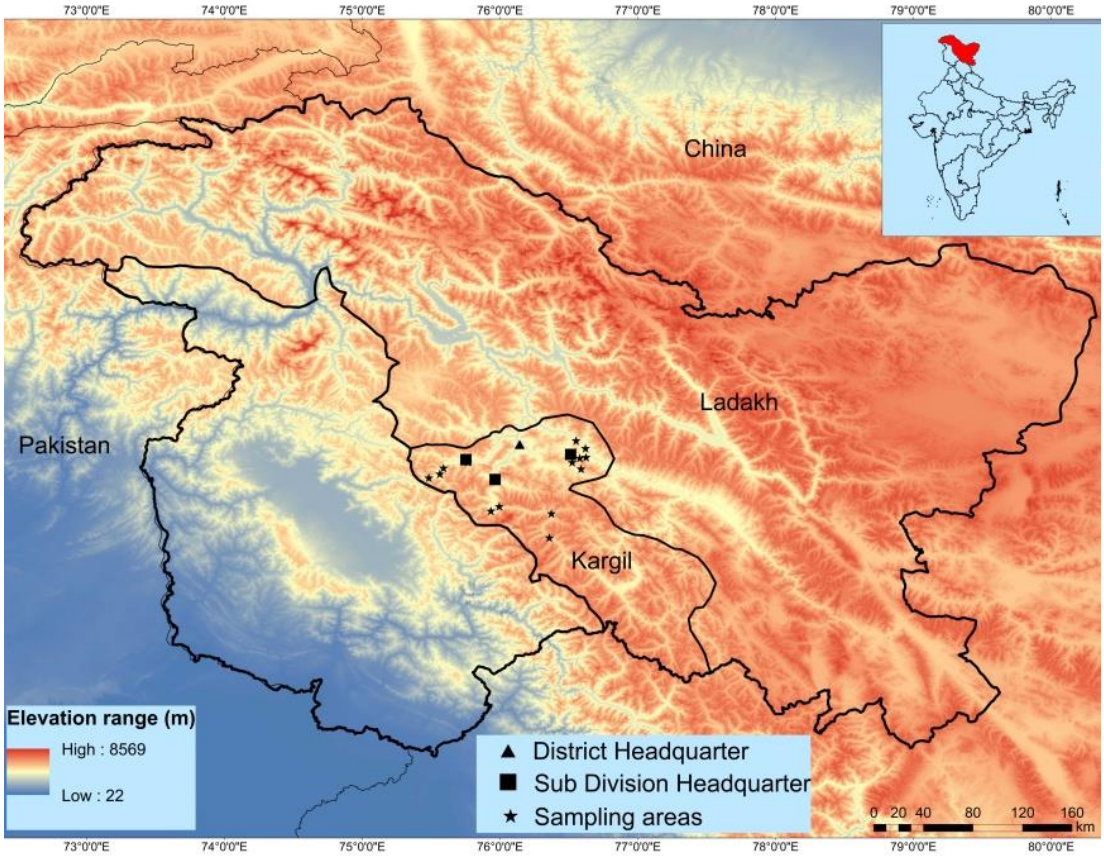


Image 2.1: Map of study area

2.1.2. Climate

Climate in the region is characterised by extreme variability in seasonal precipitation and temperatures attributed to its location and high elevation. Being in the rain shadow and leeward side of the Greater Himalayas it receives very little monsoon clouds thus receives little rainfall recorded up to 100 m and has been classified as a Cold Desert and divided into two provinces viz Ladakh Mountain and Eastern plateau (Rodgers and Panwar 1988). Precipitation is majorly in the form of snow governed by western disturbances in winter. However, areas such as Suru and Drass in the south western region receive relatively more precipitation and are greener in comparison to areas such as Changthang in the east and Nubra in the north east (Hartmann,1983). Temperature is characterised by extreme cold (- 40^{o} C) in winter and heat (+ 38^{o} C) in summer and by diurnal extremes of hot days and cold nights. Owing to its dry and barren state the relative humidity ranges between 25% - 50% from April to October (Pai et al., 2014).

2.1.3. Flora

Vegetation of Ladakh is classified as dry alpine scrub, desert steppe, riverine scrub and marsh meadows. Vegetation is sparse, with low primary productivity changing gradually with elevation from agro forest communities dominated by tree species such as *Populus spp*. and *Salix* spp., at lower elevation to moist alpine scrub communities dominated by *aconitum* spp., *Anaphalis brusus, Crepis multicaulis, Hippophae rhamnoides* and *Myricaria* spp. species at mid elevation. Whereas moist alpine pastures reaching up to snowline are dominated by graminoid species *Melica persica. Poa spp*., in addition to species such as *Artemesia* spp., *Medicago sativa, Plantago lanceolata* and *Saussurea ceratocarpa* (Hartmann; 1977; Behera et al., 2014).

Although, devoid of forest cover isolated patches of *Juniperus wallichiana*, birch *Betula jacomonti* and pine *Pinus wallichiana* (Banoo et al., 2023) are reported from the region. Nevertheless, a total of approximately 1250 species of vascular plant are known to occur in Ladakh (Kilmes and Dickore, 2005).

2.1.4. Fauna

Located at the junction of Palaearctic and Oriental biogeographic zones most of the mammalian faunal assemblage of the region are of Palaearctic origin with an exception of cape hare *Lepus capensis* which is of Ethiopian origin. Moreover, high diversity of mammalian fauna in the region is attributed to its location and juxtaposition of the Tibetan plateau and Hindukush – Karakoram Mountains; inclusive of Zanskar and Ladakh mountains (Namgail, 2009). A total of 45 mammalian fauna is reported from the region comprising twelve carnivore species and 20 herbivores representing 6 families and 11 genera. Presence of bats are also reported from the region. The region harbours species of high global conservation importance such as snow leopard (*Panthera uncia*), Himalayan brown bear (*Ursus arctos isabellinus*), Tibetan wolf (*Canis lupus chanco*), Pallas's cat (*Otocolobus manul*), Eurasian Lynx (*Lynx lynx*), red fox (*Vulpes vulpes*)and otters (*Lutra lutra*) to mention a few. Besides the region is rich in wild herbivores such as the blue sheep (*Pseudois nayur*), Himalayan ibex (*Capra sibirica*), Ladakh Urial (*Ovis vignei vignei*), long tailed and Himalayan marmots (*Marmota cudata & Marmota himalayana*).

2.1.5. Land use practices

Depending upon elevation, topography and land use systems Ladakh can be broadly divided into three agro – eco regions; elevated open plains of eastern Ladakh (AE-1; 4000 – 5500), single crop areas (AE-2; 3000 – 4000 m) and two crop areas with warmer climate (AE:3; 2600-3000 m). Inhabitants are nomadic pastoralists in AE-1 agro – eco regions whereas in lower rugged valley areas from (2600-4000 m) inhabitants are mostly agro – pastoralists. People cultivate food and fodder crops such as barley *Hordeum vulgare*, wheat *Triticum aestivum*, lentils *Lens esculenta*, peas *Pisum sativum*, *alfalfa Medicago* spp. and buckwheat *Fagopyrum esculentum*. Cultivation of buckwheat is abandoned less while oats *Avena sativa* is a new addition. Likewise livestock varieties includes cow *Bos taurus*, yak hybrids *Bos grunniens*, horse, mule, donkey; *Equus* spp., sheep *Ovis* spp., goat *capra* spp. and poultry (Image 2.2; 2.3).

Like the Changpa herders of eastern Ladakh migratory, Bakerwal herder and Chopan (traditional hired herders of Kashmiri livestock traders) use the rangeland of western Ladakh as their summer pasture from May-August. They are mostly found in Drass and Suru Valley area. They rear livestock such as sheep, goats and horses. They bring thousands of livestock in these valleys every year. Their occupation of these summer pastures may have been ensuing from the expansion of the princely state of Jammu and Kashmir under General Zorawar Singh Kahluria in 1840.

Image 2.2: Land use system in study area agriculture

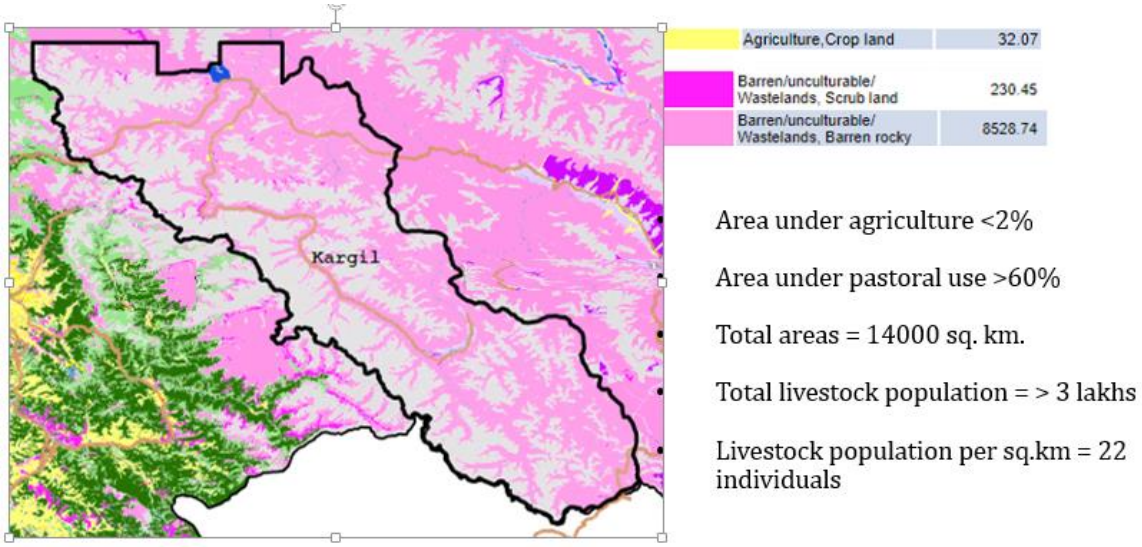


Image 2.3: Acreage under agriculture and pastoral use in the study area

2.2. Field methods

2.2.1. Study sites

Data on agro pastoral practices were collected from five valleys, namely Drass, Suru, Chiktan, Shayok and Gya –Meru. Moreover, perception on rangeland dependency and factor attribution to changes in agro pastoral practices were collected for Drass valley only. Likewise, data on vegetation structure and composition pertain to Drass valley too. For spatio – temporal variation in livestock depredation data was collected from all the valleys but analysis of spatio temporal was further analysed for on Wakha in Chiktan valley only. Here all the three carnivores, snow leopard, wolf and bear killed livestock, whereas in other valleys depredation was either by only bear or by snow leopard and wolf only.

2.2.2. Agro pastoral practices and land use

The study was based on semi structure interviews (Namgail et al., 2007) in five Valley of Ladakh (Image 2.4). A total of 519 respondents (228 male; 291 female) were

interviewed in year 2018-20 to gather information on demography and agro – pastoral production system in Ladakh. These 519 household had a total population of 4050 individuals comprising 2005 males and 2045 females. We interviewed 227 respondents (100 Male: 127 female) in Suru, 117 (62:55) in Drass, 80 (14:66) in Chiktan, 56 (29:27) in Shayok and 39 (23:16) respondents in Gya Valley. In each village we randomly interviewed 30% household. We stratified our sampling in each village based on its location at the periphery, in the middle and centre of the village. All respondents were individuals who often visited rangeland and knew about past and present agro-pastoral practice. All responses were noted on field interview forms for every individual. For open ended questions response were noted distinctively to understand pattern of change and drivers. Parameters such as participation of people in agro pastoral practice, name of crops cultivated, livestock reared, trees planted, mountain resources collected, and animals in conflict were noted. We collected data to ascertain spatio-temporal variation in agro – pastoral in the valley. Apart from it we collected date on people perception about agro-pastoralism.

Image 2.4: The author while conducting questionnaire survey in the study area

2.2.3. Vegetation sampling

Data was collected over two vegetation growth season from June – August (2018 and 2019). In order to study plant structure and composition we divided areas in low, medium and high gradient of anthropogenic pressure i.e. livestock grazing. Overall, two hundred forty five quadrats were laid in the area. This comprised of 90 quadrats in low, 88 in Medium and 67 in high livestock grazing intensity areas. Quadrat size was 1 $m^{2.}$ (Image 2.5). In each quadrats we recorded number of species and physical parameters such as landscape type, aspect, slope, elevation (Mueller-Dombois D, 1974; Rawat & Adhikari, 2005; Bagchi & Ritchie, 2010; Namgail et al., 2012). Additionally, percent cover viz. vegetation, bare soil and stone or rock in each quadrat was estimated visually. Vegetation data were collected proportionately keeping in view the varying physical parameters in the rangeland. Landscape type classification was based on Kala & Mathur (2002) and Rawat & Adhikari (2005). The plants were identified using relevant literature (Dhar and Kachroo 1983; Chowdhery and Wadhwa 1984; Polunin and Stainton 1984; Murti 2001; Dvorský et al. 2018; Shukla and Srivastava 2020) and online database such as Plants of World Online [https://powo.science.kew.org/]). All, plant species were photographed for their identification and subsequently verified with the help of experts.

2.2.4. Habitat use and vigilance behaviour sampling

The study spanned over two active seasons (May to September) in 2018 and 19. Data on marmot behaviour were collected in 2020 in the September, resource pinch period to assess difference in marmot behaviour with respect to livestock grazing. We identified areas with high(>2500 livestock), medium (700) and low (300) livestock

grazing areas (Poudel et al., 2015). Trail transects of varying length were established in these areas depending upon accessibility. Overall eleven trails comprising, three in high; Mimamarg 1 & 2, six in medium; Gumri, Lhamochan, Tangole and Parkachik and three in low; Matayin, Penzila and Rangdum, were walked to gather comprehensive data on habitat use. Transect length ranged from 2 to 7 KMs in high, 5 to 9 KMs in low and 2 to 6 KMs in medium use areas. In each areas we collected data considering topographical heterogeneity to avoid sampling bias and less or over representation of different bio physical parameters. At each transects we recorded presence of marmots in addition to its bio physical attributes (Zhou et al., 2021; Ferrari et al., 2009). Bio physical attributes included habitat type, terrain or topography, slope, aspect, position, elevation and vegetation cover (Namgail et al., 2007b; Namgail, et al., 2008; Poudel et al., 2016). Habitats were categorised into five types; agriculture fallow, alpine meadow, scree slope, moraines and marshes (Kala & Mathur, 2002; Rawat & Adhikari, 2006). Likewise, position were categorised as bottom, lower, middle, upper and top. Whereas terrain types included; gentle, broken, moderately broken and heavily broken types.

Likewise, to quantify impact of livestock on marmot behaviour vis-à-vis vigilance and foraging behaviour we recorded group size of marmots along transects in addition to its distance from livestock in each areas (Poudel et al., 2016). Focal animal sampling for 240 minutes on marmots in 21 colonies comprising 120 individuals were sampled. Group composition was not noted due lack of identification in the field. We used focal animal sampling method to observe marmot individuals (Altmann, J., 1974). In each group only adult individuals were sampled. Each focal marmot was observed for two

minutes and their activity per second were recorded using hand held device (Poudel et al., 2016). Observations were conducted during different times of the day (morning, midday and late afternoon) to avoid sampling bias.

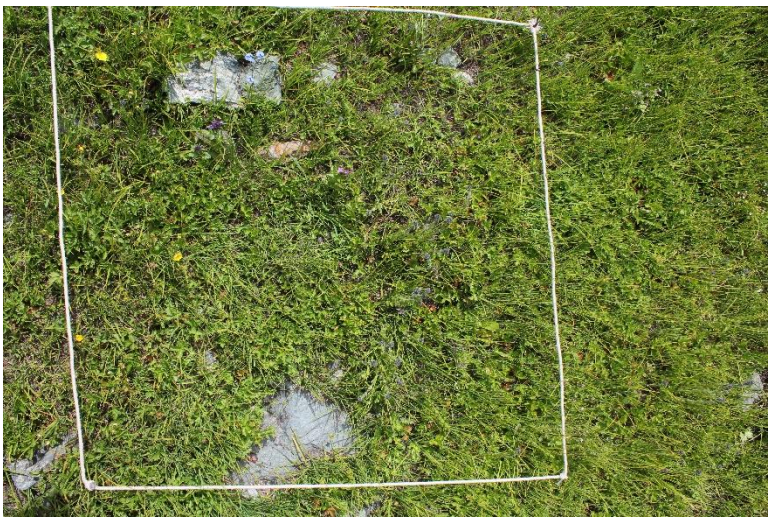


Image 2.5: Vegetation sampling in the study area

2.2.5. Spatio – temporal variation in livestock depredation

Data were collected from six hamlets: Gainchoks, rGyal, Kharkhor, Chuskor, rGyalkhang and Wadoo in early 2016. Data on people's attitude towards large carnivores were collected in late 2017. We carried out open – ended structured interviews. Both women and men from 88 households took part in the questionnaire survey. We stratified the area into three zones: valley mouth (Zone-1), valley bottom (Zone-2) and open areas without obstructions (Zone-3). Given that vulnerability of livestock to predators varies across a village, we randomly selected different households in the outer, middle and inner areas of a village (Namgail et al., 2007).

We sought permission from the interviewees before starting the interviews. For every

livestock depredation case, we recorded the zone it was killed in, carnivore involve, livestock type, number killed, year, time and site of depredation (Namgail et al., 2007; Bhatnagar et al., 1999). We recorded distance of the house from the nearest gorge opening to measure vulnerability and signs used to authenticate predator in case killing occurred in their absence. Besides this, we interviewed six elders from the survey villages to understand livestock herding practices in the Valley. Additionally, in order to evaluate economic loss per household due to depredation, market survey was carried out to know market value of different livestock types.

Chapter 3: Agro – pastoralism in Trans – Himalayan region of Ladakh: Changes over decades

3.1. Introduction

The Trans-Himalayan mountain region in Ladakh is characterised by low primary productivity (Rawat and Adhikari, 2006). Here subsistence agriculture is still mainstay of the economy and land use can be broadly divided in three production systems: nomadic, transhumance and agro-pastoralists. Livestock production is more intensive in areas above 4500 metre elevation whereas agriculture practice is possible in areas of the regions which have easy access to water. Though isolated in terms of connectivity it remained a centre of trade among Central Asian nations through the silk route (Rizvi, 1999). Within Ladakh trade was in the form of barter and food grains from lower valleys were exchanged with wool and salt form higher altitude areas. Apart from it rice and spices were obtained in exchange with products such as apricot and live animals (Rizvi, 1999). Operation of all barter trade came to halt with the independence of India in 1947 and later due to escalation and war with china during 1962 remains of this trading system disappeared altogether (Rizvi, 1999: Fox, 1994, Namgail, 2010). Also livestock movement at the eastern border stopped completely (Namgail, 2010) and a village was totally abandoned in western region, namely Batakoul, Drass Valley. Thus, due to its strategic importance and with the growing political tension at the borders at its eastern and western border military presence increased. Till now three wars are fought in the region with China and Pakistan. The last war in year 1999 was fought along its western border in Kargil with Pakistan. In order to ease the movement of army personnel, improve the living condition of people

and administrative infrastructure in the region, it was connected to peninsular India in year 1974 through a motor-able road via the Zoji-La near Kargil. Later in the year 2000 Leh-Manali road was also opened for transport and travel purposes. These political changes and connectivity followed by socio-economic transition transformed and modernised traditional lifestyle and land use system in the region. Livestock composition changed and agriculture practices were also modified with more inclination on cultivation of cash crops, garden vegetables and tree plantation (Fox, 1994: Yamaguchi *et al.,* 2016). The change in traditional life style is undeniable greater in areas especially along the new transportation corridors. However studies on the impact of these changes on wildlife conservation and natural resource use in the rangeland is limited. Most studies show increasing concern over livestock population which lead to completion with wild herbivores (Bhatnagar *et al.,* 2006: Namgail *et al.,* 2010). However, seasonal variability puts restriction on continual use of rangelands by livestock thus reducing competition with wild animals (Fox, 1994). Also wild herbivore population increase especially Kiang is considered as threat to livestock production as people perceive it as competing with the limited grazing resource (Bhatnagar *et al*., 2006). Though hunting is non-existent, the issue of livestock killing by large carnivores and crop damage by herbivores can be serious challenges for conservation of range resources and wildlife (Fox, 1994; Namgail *et al*., 2007).

Currently due to better connectivity and governance, presence of army and increasing tourism and infrastructure development agro-pastoralism has been affected hence agro – pastoral production system. We assessed current trend of agro – pastoral production system and factors influencing its dynamics. Year 1999 was used as reference year to determine change in agro – pastoral production system over two decades. In the

chapter based on the quantitative and qualitative data we argue agro – pastoral production system has changed and is likely to change further.

3.2. Data analysis

3.2.1. Changes in agriculture and livestock population and people perception

Proportionate changes in agriculture and livestock population was estimated by dividing crop types cultivated by each household divided by the total households. Similar calculations was done in order to estimate change in livestock types reared by households and their population. Likewise average hers size was calculated for each livestock type for comparative analysis.

3.2.2. Status of dependency on rangelands

We added the responses provided by the respondents it by total respondents to assess dependency and status of mammals in the region.

3.2.3. Group composition of Asiatic ibex

We used scan sampling to find ibex along river and valleys and used vantage points near villages to find Asiatic ibex. We used 20X60 spotting scope and 10X45 binoculars to identify individuals in a group. For each group sighted we recorded number of individuals in the group. In addition we recorded number of adult male, adult female, young male, young female, yearlings, and lambs. However, in order to determine female to young ratio we included yearling and lamb together. We classified ibex into different groups based on horn length and girth, body color and size. We used classification provided by Bhatnagar (1997) to classify an ibex group with a slight modification and classified individuals into different age class such as: –

Adult males – individuals with horns curved at the tip forming a half circle, whereas young males include individuals with border horn base and tips forming an arc at the tip.

Adult female – individuals with a thin horn base compared to young males without tines and its slender shape whereas young females included individuals with thin horn and size smaller than an adult female.

Yearlings – individuals with horn length shorter than 5 inches whereas lambs were without horns or were of 2-3 inches. Likewise, group composition was calculated by adding number in each class for each species observed in field. Data analysis for this part was conducted using, Microsoft Excel Statistics Calculator.

3.3. Results

3.3.1. Demography and people participation in agro – pastoral practice in Ladakh

A total of 519 respondents (228 male; 291 female) were interviewed in year 2019-20 to gather information on demography and agro – pastoral production system in Ladakh. These 519 household had a total population of 4050 individuals comprising 2005 males and 2045 females (Table 3.1). We interviewed 227 respondents (100 Male: 127 female) in Suru, 117 (62:55) in Drass, 80 (14:66) in Chiktan, 56 (29:27) in Shayok and 39 (23:16) respondents in Gya Valley. Overall 63% respondents reported living in nuclear households whereas 37% reported living in joint families. Nuclear (NF) to joint family (JF) ratio for each Valley were 56:44 in Suru, 47:53 in Drass, 74:26 in Chiktan Valley, 98:02 in Shayok and 82:18 in Gya Valley (Table 3.1).

Table 3.1: Demographic variation in five Valleys of Ladakh

Valleys	Total households	Number of member	Male	Female
Suru	227	1833	897	936
Drass	117	1043	525	518
Chiktan	80	631	313	318
Shayok	56	333	164	169
Gya	39	210	106	104
Overall	519	4050	2005	2045

Overall we found thirty three percent individuals involved in agro pastoral practices, 39% in studies (school, college or universities), twenty percent opting for others or alternate livelihood sources and remaining 8% in government jobs. Percentage of people involved in agro – pastoral practices in Shayok valley was not available (na). In Suru Valley percentage of people in govt. job was lower (5%) in comparison to other valleys whereas Drass has highest (11%). In addition involvement of people in other alternative livelihood source was highest in Gya Valley (32%) and lowest in Suru Valley (16%). Likewise percentage of people in studies was highest in Drass (42%) and lowest in Gya Valley (24%). However, in terms of people involvement in agro – pastoralism it was similar in all the Valleys (Table 3.2).

Table 3.2: People participation (%) in different area of activities in Ladakh

	Agro – pastoralism	Studies	Govt. Jobs	Others
Suru	38	41	5	16
Drass	35	42	11	13
Chiktan	34	35	7	24
Shayok	na	35	10	55
Gya	34	24	10	32
Overall	33	39	8	20

Others: include alternative livelihood sources such and daily wage works, shop and tourism related activities; **na:** not available

3.3.2 Agriculture Production in Ladakh: Change over two decades

A total of 10 crops used as food and fodder are cultivated in Ladakh. Barley a staple crop and peas are cultivated in all the Valleys surveyed. Oats and alfalfa are cultivated in four Valleys excluding Shayok Valley whereas lentil and buckwheat are cultivated in Suru, Drass, and Chiktan Valley. Wheat is cultivated in Suru and Chiktan Valley whereas tCha, tSe-tSe and Garaz are grown only in Chiktan Valley.

Crop diversity in Chiktan Valley was high where all 10 crops were cultivated followed by Suru (7), Drass (6), Gya (4) and Shayok (2). Crop diversity has increased in all the valleys except Drass Valley where cultivation of three crops has been abandoned namely wheat, tCha and tSe-tSe. Oats is a new addition to crop diversity in all the four valleys except Shayok Valley. Diversity of crop cultivation in Shayok has remained static i.e. two crops only (Table 3.3).

3.3.2.1. Difference in agriculture production in five Valleys of Ladakh

Overall, in Ladakh crop diversity has increased over the two decades. However its cultivation household wise has decreased. Traditional food and fodder crops such as buckwheat, wheat, peas and lentils has been abandoned by many households whereas new fodder crop such as oats has been adopted to overcome fodder shortages and due to its easy growth (Table 3.3).

3.3.2.2. Suru Valley

In the past, i.e. before year 1999, six crop species namely barley, wheat, peas, alfalfa, lentils and buckwheat were cultivated. Now with oats as a new addition this has increased to seven crops species. Out of the 227 households interviewed, with the exception of barley crop which is cultivated by 96% of the households, we observed decrease in cultivation of crops such as wheat (94% before 1999 to 87% in 2021) and

Peas (92% to 78%). Crop species such as Lentils (15% to 5%) and buckwheat (11% to 1%) are almost abandoned by people in Suru Valley. tCha, tSe-tSe and Garaz were never cultivated by people in Suru Valley. On the contrary 56% of households have started cultivating oats which was 0% in year 1999 (Table 3.3)

3.3.2.3. Drass Valley

In the past two decades Drass Valley has witnessed decline in number of diversity of crop species cultivated. In year 2021 only six crop species were cultivated out of the eight crop species cultivated in year 1999. We interviewed 117 individual in the Valley and found that most of the households (91%) cultivated barley where as 79% households cultivated alfalfa. Most apparent decline has been observed in cultivation of peas (89% to 26%), lentils (67% to 17%) and buckwheat (80% to 2%). Interestingly in the Valley before year 1999 0% of households cultivated oats but this rose to 81% of the households in year 2021. Here oats cultivation is preferred due to its high fodder value and requiring relatively less amount of human resource (Table 3.3)

3.3.2.4. Chiktan Valley

Chiktan Valley has the highest crop diversity where all the ten crop species of food and fodder are cultivated. Here too oats is a new addition to the traditional crop species. However, if we exclude low lying villages namely Kukshow and Sanjak where double cropping season enables cultivation of varied crop species, the number of crop species cultivated lowers to six species namely Barley, wheat, oats, alfalfa and lentils. We interviewed 80 individuals in Chiktan Valley and found that100% of households cultivating barley followed by wheat 90%, peas 88%, alfalfa 66% and garaz 23%. We observed decline in cultivation of crop species such as buckwheat (16% to 6%), lentil

(13% to 9%) and Tse-tSe (14% to 6%). Oats which was not cultivated prior to year 1999 is now cultivated by 34% of the total households interviewed (Table 3.3).

3.3.2.5. Gya and Shayok Valley

Crop diversity was very less in these two Valleys in comparison to the other three Valleys discussed above. In Gya – Meru Valley only four species are cultivated which was three prior to year 1999. Here oats is a new addition. However in Shayok Valley only two crop species are being cultivated. Barley and peas in Gya Valley are cultivated by 100% and 82% households respectively whereas in Shayok Valley 82% of the households cultivate barley and peas is cultivated by 46% of the households (Table 3.3).

Table 3.3: Percentage difference in crop cultivation in Ladakh

	Suru		Drass		Chiktan		Shayok		Gya	
	2021	1999	2021	1999	2021	1999	2021	1999	2021	1999
Barley	96	96	90	91	100	100	82	82	100	100
Wheat	87	94	0	4	90	93	0	0	0	0
Peas	78	92	26	89	88	94	46	46	95	95
Oats	56	0	81	0	34	0	0	0	3	0
Alfafa	19	12	79	81	66	69	0	0	3	3
Lentils	5	15	17	67	9	13	0	0	0	0
Buckwheat	1	11	2	80	6	16	0	0	0	0
Cha	0	0	0	1	3	5	0	0	0	0
Garaz	0	0	0	0	23	30	0	0	0	0
Tse-Tse	0	0	0	1	6	14	0	0	0	0

3.3.3 Livestock production system in Ladakh

3.3.3.1. Livestock composition and herd size in different Valleys of Ladakh

We interviewed a total of 519 households which comprised 227 households from Suru, 117 from Drass, 80 from Chiktan, 56 from Shayok Valley and 39 from Gya Valley.

Six livestock types are reared by agro – pastoralists in Ladakh. In Shayok Valley all livestock types are reared whereas in Suru, Chiktan and Gya Valley five livestock types are reared except mule. In Drass, except for mule and donkey, four livestock types are reared. We compared decrease on livestock rearing practice in three Valleys namely Suru, Drass and Gya Valley. In Suru there is no change in rearing of cow (100%) where as in Drass and Chiktan it has decreased from 100% to 94% and 78% respectively. Highest drop has been observed in shoats rearing in Drass Valley (85% to 28%) followed by Chiktan Valley (95% to 79%) and Suru Valley (89% to 82%). Likewise yak rearing has dropped from (73% to 33%) in Suru Valley, (55% to 21%) in Drass Valley and it has dropped from (94% to 35%) in Chiktan Valley. Similarly, horse rearing has dropped from (71% to 3%) in Suru Valley, (68% to 42%) in Drass Valley and in Chiktan Valley it has dropped from (56% to 3%). Rearing of Donkey has also dropped. In Suru Valley it has dropped from (37% to 4%), in Drass Valley from (7% to 0%) and in Chiktan Valley from 68% to 14% (Table 3.4).

Table 3.4: Difference in households rearing different types of livestock in Ladakh

	Suru Valley		Drass Valley		Chiktan Valley		Shayok Valley		Gya Valley	
Livestock	1999	2021	1999	2021	1999	2021	1999	2021	1999	2021
Cow	100	100	100	94	100	78	0	91	0	87
Shoat	89	82	85	28	95	79	0	86	0	59
Yak Hybrids	73	33	55	21	94	35	0	71	0	36
Horse	71	3	68	42	56	3	0	34	0	59
Donkey	37	4	7	0	68	14	0	48	0	3
Mule	0	0	3	0	0	0	0	7	0	0

We found an overall decrease in livestock population over two decades in Ladakh. In Chiktan Valley overall livestock population has decreased 71% from the year 1999

mark whereas in Drass Valley it has decreased to 70%. In Suru Valley a decrease of 32% in livestock population has been observed (Table 3.5). As the overall livestock population has decreased and people have also abandoned rearing certain livestock types over the years we found a concomitant decrease in livestock population over the two decades. In Suru Valley sheep and goat henceforth – shoats population has decreased 24% whereas in Drass Valley its population has decreased 78% over the two decades. Similarly in Chiktan Valley its population has decreased 72%. Cow population in Suru Valley has decreased 19%, in Drass Valley 22% and Chiktan Valley 48%. Similarly yak hybrid population in Suru Valley has decreased 59%, in Drass Valley 71% and in Chiktan Valley 65%. Horse population in Suru Valley has decreased 13%, in Drass Valley 30% and in Chiktan Valley 33%. Rearing of Donkey in Drass Valley has been abandoned whereas in Suru and Chiktan Valley a decrease of 90% is reported. Mule was never reared in Suru and Chiktan Valley whereas in Drass Valley it rearing has been completely abandoned (Table 3.5).

Table 3.5: Decrease in livestock population in Ladakh

	Suru Valley		Drass Valley		Chiktan Valley	
Livestock	1999	2021	1999	2021	1999	2021
Shoat	3349	2533	2346	506	2568	727
Cow	752	610	265	206	246	129
Yak Hybrids	323	134	113	33	189	66
Horse	322	13	211	148	3	2
Donkey	133	13	12	0	210	20
Mule	0	0	12	0	0	0
Total	4879	3303	2959	893	3216	944

In addition to this in all the Valleys we observed variation in herd size of all livestock types. Gya has the highest herd size of shoats (29.28) followed Shayok Valley (21.50). Similar variable trend in herd size of other livestock types were also observed. As data

on livestock composition from Shayok and Gya Valley were not available we compared difference in herd size over two decades for livestock types in three valleys namely Suru, Drass and Chiktan Valley. We found decrease in magnitude of average herd size of livestock types. Largest decrease was observed in herd size of shoats in Drass and Chiktan Valleys whereas in Suru Valley its decrease is relatively less. In Suru Valley herd size of shoats decreased from 14.88 heads to 10.23 heads per households. However in Drass Valley herd size of shoats has decreased for 20.94 heads per household to 4.53 heads whereas in Chiktan Valley livestock herd size has decreased from 31.70 livestock heads to 8.97 heads per household. Likewise herd size of other livestock types such as yak hybrids, horse and mule has decreased (Table 3.6).

Table 3.6: Variation in average herd size of livestock types in Ladakh

	Suru Valley		Drass Valley		Chiktan Valley		Shayok Valley		Gya Valley	
Livestock	1999	2021	1999	2021	1999	2021	1999	2021	1999	2021
Shoats	14.88	10.23	20.94	4.53	31.70	8.97	0.00	21.50	0.00	29.28
Cow	3.31	2.68	2.36	1.83	3.07	1.61	0.00	4.64	0.00	3.23
Yak Hybrid	0.96	0.38	1.03	0.30	1.40	0.48	0.00	2.92	0.00	1.75
Horse	1.59	0.06	1.90	1.33	1.13	0.02	0.00	1.01	0.00	1.58
Donkey	0.69	0.06	0.54	0.00	2.87	0.27	0.00	1.48	0.00	0.17
Mule	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.07	0.00	0.00

3.3.4. Dependency on rangeland

People in the valley are dependent on rangeland in terms of livestock grazing, collection of fuel wood, fodder and food plant. Livestock grazing in the rangeland is maximised for a period of six months beginning in May till October. During this season all livestock are grazed in rangeland. Where as in winter all livestock are stall fed except for some horse which are left unattended. Fodder and fuel wood collection areas are allocated to each household and they hold right over these range resources.

Though there is no restriction on livestock rearing in these allocated range areas. The dependency of people on rangeland in the Valley varies with respect to resource use as only 3% household are dependent on rangeland for fuel wood, 38% for fodder plant collection, 52 % for food plant collection and 96 % for livestock grazing.

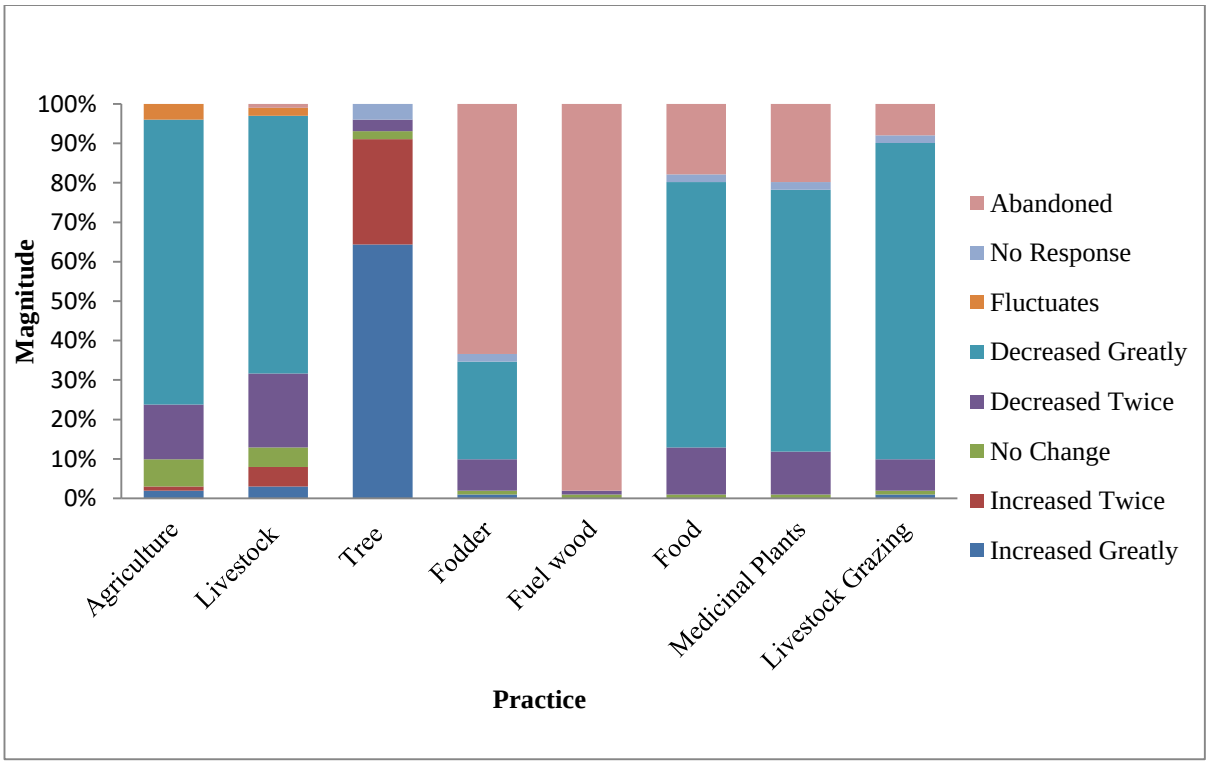


Figure 3.1: Change in agro-pastoral production and people dependency on rangeland in Ladakh

3.3.5. Mammal distribution in Ladakh

A total of twenty groups in seventeen grazing units (GU) comprising 193 individuals were sighted in the rangeland. In Suru i.e. the high gradient we sighted eleven groups in eight GU comprising 96 individuals. However, in the low gradient, which included five GU in Drass and four GU in Bodkharbu, a total of 97 individuals in 9 groups were

sighted. Our findings are based on ibex group sighted in these gradients in winter season only. We did not encountered ibex during summer season in these areas.

Over all group size ranged from 3 – 32 individuals with an average group size of 10 individual per group. Besides, group size in the two gradients ranged from 3 – 21 in high and 4 – 32 in the low gradient. The mean group size was 11 in the low gradient and 09 in high gradient. Over all female to young ratio was 01: 0.58 whereas as female to lamb ratio was 01: 0.75. We found differing female to young and female to lamb ratio in the gradients. In the high gradient female to young ratio was 01: 0.41 and female to lamb ratio was 01: 0.61 whereas female to lamb ratio in low gradient was 01:0.82 and female to lamb ratio was 01: 0.96 (Table 3.7).

Table 3.7: Group composition of Asiatic ibex in a gradient of agro – pastoral practice

Area	Region	Group Size	Adult Male	Adult Female	Young Male	Young Female	Yearling	Lamb
Parkachik	Suru	5	0	4	1	0	0	3
Parkachik	Suru	8	0	1	2	2	0	0
Tangole	Suru	17	4	3	2	4	4	0
Panikhar	Suru	3	0	2	0	0	0	1
Panikhar	Suru	6	1	3	0	0	0	2
Panikhar	Suru	3	0	2	0	0	0	1
Kichur	Suru	17	5	8	0	0	0	4
Kiichur	Suru	5	0	3	0	0	0	2
Khaos	Suru	5	1	2	2	0	0	2
Rgyaling	Suru	21	3	10	4	0	0	4
Sankoo	Suru	6	1	3	0	0	0	2
Matayin	Drass	32	6	10	2	3	0	12
Mushkoo	Drass	5	0	2	0	1	2	0
Goshan	Drass	13	2	4	2	1	2	3
Shimsha – Kharbu	Drass	4	2	1	0	0	0	1
Shimsha – Kharbu	Drass	8	4	0	2	0	2	0
Bod – kharbu	Bod – kharbu	11	2	1	6	0	0	2
Bod – kharbu	Bod – kharbu	7	1	4	0	0	0	2
Bod – kharbu	Bod – kharbu	9	0	6	0	3	0	0
Bod – kharbu	Bod – kharbu	8	2	1	1	3	0	2
Sum		**193**	**34**	**70**	**24**	**17**	**10**	**43**

3.3.6. Drivers of change in agro – pastoral production systems: People's perception

Five prominent factors such as human resources, division (agriculture land and livestock), climate, fodder shortages and carnivores have been described by people affecting agro – pastoral production system in Ladakh. The magnitude of impact of these factors on production system in different valleys was different. Overall lack of human resources (53%) has a major role in change in production systems, followed by fodder shortages (17%), climate (10%) and division (8%). However, 10% people did not find any problem or challenges in production systems. In Suru Valley 55% and 57 % people felt lack of human resources affecting agriculture and livestock production respectively whereas in Drass Valley (58% and 39%) people feel lack of it affecting agriculture and livestock production system. In Chiktan Valley 58% and 71% people perceive lack of human resource affecting agriculture and livestock production systems. Likewise 36% in Suru Valley, 58% in Drass Valley and 14% people perceive lack of fodder affecting livestock production. In addition to these factors 10%/4% in Suru Valley, 18%/1% in Drass Valley and 33%/0% people in Chiktan Valley perceive climate affecting agriculture/livestock production systems. People also cited factors such as division and carnivores affecting agro – pastoral production systems (Figure 2).

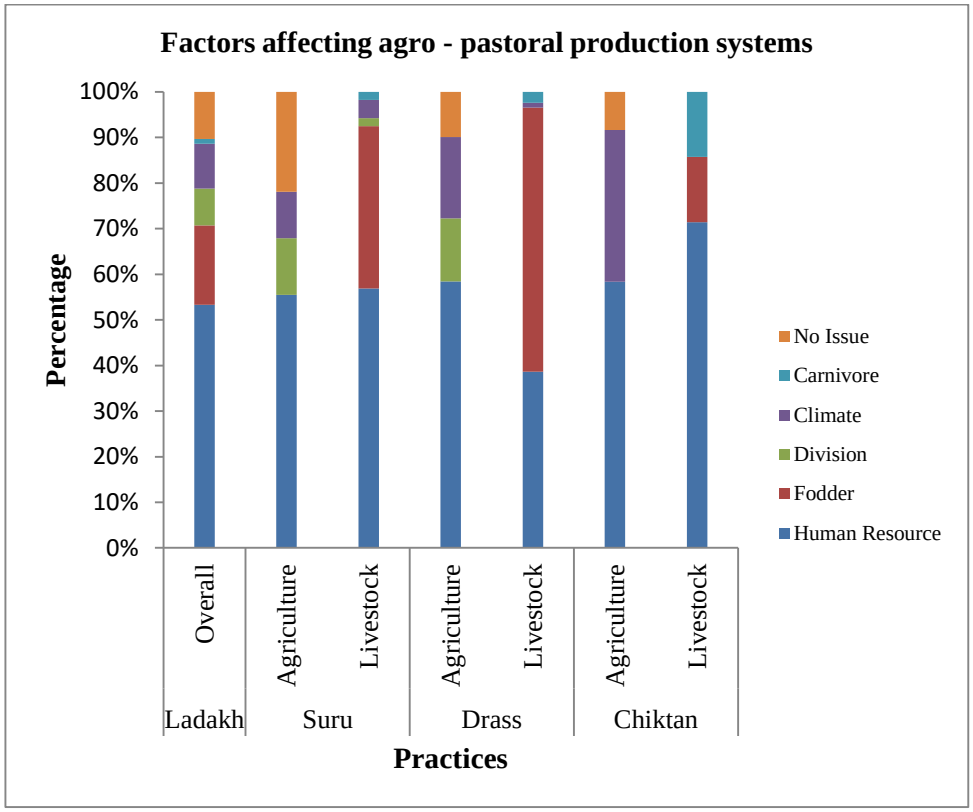


Figure 3.2: Factors affecting agro – pastoral production system in Ladakh

3.4 Discussion

Agriculture practice in the Valley though changing with respect to the needs and demands of people is still intact despite its location and market access. Though land available for cultivation has minimised due to division of land among families, there is no case of farmland abandonment as reported from Domkhar Village in Leh, J&K (Yamaguchi *et al*, 2016). Barley the main staple crop and an important fodder crop in the all the Trans-Himalayan region and Tibetan plateau is still grown by all households. The continuing cultivation of barley thus could be due to its cultural connection, fodder importance and partly due to their dietary habit, as barley is eaten every day during lunch time. Off farm employment and jobs in govt sector and army

though has led to decline in agro-pastoral production pattern yet it also form backbone for its sustenance. The money hard earned from these employment sectors is invested to hire labour during sowing, ploughing, thrashing and crop harvest and also for hiring shepherd for livestock rearing. This is in contrast to changes in Spiti Valley, Himachal Pradesh; where barley production has been replaced by green pea cultivation (Singh, 2015). Also, in eastern Tibet its cultivation has declined and replaced by imported crops (Yamaguchi, 2011). Also, crop production is likened to change in dietary habit as traditional foods are replaced by consumption for rice and wheat which are readily available in market at subsidised rates and also take less time in cooking (Fox, 1994: Namgail *et al.*, 2010; Yamaguchi, 2016). Cereal crops such as cultivation of lentils and peas and wheat has minimised as these are easily available in the market and the govt. also provide subsidy on products such as wheat. Also, in comparison to barley wheat and cereal crops are prone to climatic variation and require extra labour (Dame and Nusser, 2011) which is a big challenge in the valley due to non-farm job opportunities and education among young men and women. On the contrary, oats cultivation has overtaken their place though not completely replacing them. Its increased acreage for cultivation over time is partly due to less labour requirement in its cultivation and partly due to its fodder quality. Additionally as people have abandoned fodder collection from the mountain this adaptation can be considered as a clever strategy, enhancing fodder availability to livestock which are stall fed for over six months due to snow in the rangeland.

Three main factors, war, fodder shortage and lack of human resources have contributed to decline in livestock composition and herd size in the valley. Apart from it market connection and economic value also change livestock production (Namgail, 2010;

Yamaguchi, 2016). Sheep and goat population has changed drastically post 1999 war, declining by 70% after 1999 war. Two villages in the area namely Batakoul and are uninhabited as they have abandoned their village after war in 1965 and 1999 and no livestock and agriculture land belongs to them. In Changthang areas of Ladakh war displaced people, completely stopping across Indo – Chinese border (Namgail *et al.,* 2011). Though the livestock population is increasing in the area, it is more linked to rise in demand for Pashmina wool with lack of human resource and fodder availability are prime issues (Namgail *et al.,* 2010). Similarly, in Spiti Valley, the population of cattle, sheep, goat and horse has declined mainly attributed to lack of fodder and human resource (Singh, 2015). War in a livestock production system impacts mobility pattern of livestock and leads to conflict among livestock herders, as observed in Afghanistan and it neighbouring countries (Namgail *et al.*,2010;Kruetzmann and Schutte, 2011). In the study area though there is no conflict of interest among villagers, livestock mobility was limited due to army presence. Change in the population of cattle and horse is insignificant post war. Rearing of horse ensures employment of an individual as porter in the army, thus in a way army presence is having positive impact on livestock husbandry in the valley thus sustaining agro – pastoralism. Cattles requires less labour in comparison to sheep and goat and provide several goods and services in the form of dairy products, wools and manure. Yak and horse are free ranging in the region except for milking yaks which are given similar attention like cattle which are stall fed in all seasons. Poultry rearing has declined sharply in the Valley solely due to its killing by brown bear. People stopped rearing it as they feared attracting bear in their home. In view of these challenges it would be difficult to revive poultry, sheep and goat population in the valley without policy intervention. As the

young generation don take part in this work due their education it is likely they won't be acquainted with the traditional knowledge of herd management, thus abandoning it.

Chapter 4: Vegetation structure and composition along the gradient of anthropogenic pressures

4.1. Introduction

Vegetation in the rangelands of Trans - Himalaya comprises sub alpine, wet meadows, desert steppe, riverine, scrub and wet meadow communities (Hartmann, 2009) characterised by low primary productivity (Rawat & Adhikari, 2005) due to rain shadow effect of the Himalaya (Image 4.1). Asteraceae is the dominant family, with preponderance of herbaceous perennial growth forms Shrubs and trees are less in abundance (Rawat & Adhikari, 2005). Lying in the rain shadow of the Himalaya, vegetation composition in the region reflects an intricate interaction between human activities, particularly livestock grazing and climate (Dvorskỳ et al., 2011; Namgail et al., 2012). Therefore we find a dominance of hemicroptophytes in its vegetation structure (Dvorskỳ et al., 2011). Earlier studies have provided details on vegetation composition in the region (Kala & Mathur, 2002; ;Rawat & Adhikari, 2005; Klimeš & Dickoré, 2007; Klimešová et al., 2011; Kala, 2011). Studies have also assessed vegetation composition in relation to livestock grazing in the region. In their study on rangelands vegetation of eastern Ladakh Rawat & Adhakari (2005), conclude that although rangelands status is stable, preponderance of graminoids indicates biotic pressure and long grazing history in the region. Namgail et al., (2008;2012) have reported decrease in forbs density due to high livestock grazing. Namgail et al., (2007;2008) also highlight the adverse effect livestock grazing and their presence on habitat use by Tibetan argali and dietary habits of Tibetan gazelle in the region.

However, most of the studies pertains to eastern Ladakh region and there is no detailed study on vegetation composition and impact of livestock grazing on rangelands of western Ladakh.

In this study we aim to address this gap and report on vegetation composition in western Ladakh. Additionally, we try to understand the impact of livestock grazing on plant species richness and community structure. Local communities are dependent on the rangelands for fuel wood, fodder, medicinal and food plants besides livestock grazing. The rangelands in western Ladakh are also used by migratory pastoral communities viz., Bakerwal and Chopan from Kashmir. Here, livestock and wild mammals share the commons and influence dynamics of vegetation composition. Mammalian fauna of conservation importance, dependent on these rangelands includes threatened species such as Himalayan brown bear, Himalayan musk deer and long tailed marmots to mention a few. This chapter deals with a detailed account of vegetation structure and composition in Drass valley. Major questions addressed were difference in vegetation structure and composition along gradient of anthropogenic pressure in addition to abiotic factors.

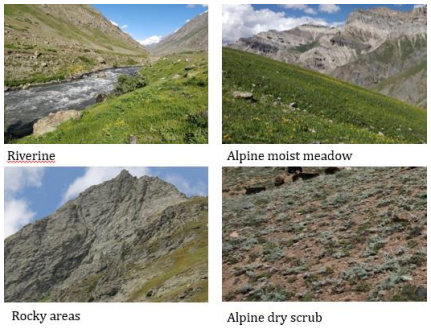


Image 4.1: Vegetation types in the study area

4.2. Data Analysis

4.2.1. Vegetation sampling

Mean species richness and vegetation cover was estimated by adding their proportionate numbers and percentage cover per quadrats. We used ANOVA test to find significant difference in species richness and vegetation cover across varying level of grazing intensity. Further, performed post – hoc (Tukey method) multiple comparison of species richness and vegetation cover across varying level of grazing intensity. For landscape type classification we followed Kala & Mathur, (2002).

4.2.2. Plant community analysis

Plant community analysis was carried out in R Studio with function "TWINSPAN", R package for Two-Way Indicator Species Analysis (Hill 1979). Plant communities were classified in elevation limit between (3700 – 4200 m). To find the impact of livestock grazing on vegetation communities we looked for the species presence in all levels of grazing intensity. In case of absence it is noted down to describe in the results.

4.3. Results

4.3.1. Plant species composition

A total of 125 species of vascular plants, belonging to 34 families and 103 genera, were recorded in the valley (Image 4.2). In terms of family dominance, contribution of species was highest in Asteraceae (14%) followed by Polygonaceae (9%), Fabaceae, Rosaceae, and Poaceae 6%) respectively and Gentianiaceae, and Lamiaceae (5%) respectively. Meanwhile, species representation in Companulaceae – Violaceae families were up to 1% only (Table 4.1). Similarly, vegetation was predominantly Hemicryptophytes (70%) followed by Therophytes (13%), Cryptophytes (11),

Phanerophytes (4%) and Chameophytes (2%). Herbaceous species (115) were the majority, with fewer shrubs (6) and shrub/tree species (3%) and ferns (1). Most of the species in terms of life span categories were perennial (98) followed by annual (19) and biennial (8; Table 4.2)

Image 4.2: Endangered plant species in the study area

Table 4.1: Vegetation composition in rangelands of Western Ladakh

Family	Genera	Species
Asteraceae	17	17
Polygonaceae	7	11
Fabaceae	6	8
Rosaceae	7	8
Poaceae	6	7
Gentianaceae	6	6
Lamiaceae	3	6
Boraginaceae	4	5
Caryophyllaceae	5	5
Brassicaceae	4	4
Plantaginaceae	3	4
Primulaceae	4	4
Apiaceae	3	3
Crassulaceae	2	3
Onagraceae	1	3
Orobanchaceae	1	3
Ranunculaceae	3	3
Saxifragaceae	2	3
Berberidaceae	2	2
Cyperaceae	2	2
Euphorbiaceae	1	2
Rubiaceae	1	2
Salicaceae	1	2
Scrophulariaceae	2	2
Campanulaceae	1	1
Caprifoliaceae	1	1
Celastraceae	1	1
Cupressaceae	1	1
Cystopteridaceae	1	1
Geraniaceae	1	1
Iridaceae	1	1
Malvaceae	1	1
Papaveraceae	1	1
Violaceae	1	1
Total	103	125

Table 4.2: Vegetation composition in terms of habit in Western Ladakh

Growth form		
	Species	Percent
Herbaceous	115	92
Shrub	6	5
Shrub/Tree	3	2
Fern	1	1
	125	
Life span		
Annual	19	15
Biennial	8	6
Perennial	98	78
	125	
Raunkiaer life form		
Chameophyte	2	2
Cryptophyte	14	11
Hemicrytophyte	88	70
Phanerophyte	5	4
Therophyte	16	13
	125	100

Percent occurrence of species in quadrats was highest (35%) for *Sibbaldia cuneata*, *Taraxacum officinale* and *Potentilla* followed by *Anaphalis nepalensis* (30%) *Astragalis* (26%), *Jacobaea sp*p. (25%) and *Ranunculus* (24%) whereas species such as *Rosa webbiana* (3%), *Thalictrum* (2%), *Cherophyllum* (1%), *Cystopteris* (1%), *Fragaria bucharia* (1%), *Lonicera* (1%), and *Jurinea* (1%) were least occurring species (Table 4.3). Further, we observed higher grass species presence in high grazing intensity areas. Herbaceous flora were prominent in low grazing areas. Fern though present, overall are less represented.

Table 4.3: Percentage occurrence of species in with respect to quadrats number in rangelands of western Ladakh

Species	Occurrence	Percentage
Sibbaldia cuneata	74	35
Taraxacum officinale	74	35
Potentilla	73	35
Anaphalis nepalensis	62	30
Astragalis	55	26
Jacobaea	52	25
Ranunculus	51	24
Veronica biloba	46	22
Geranium pratense	42	20
Grass	42	20
Oxyria digyna	32	15
Oxytropis hypoglottoides	32	15
Trifolium	31	15
Thymus	29	14
Rumex acetosa	27	13
Iris hookeriana	25	12
Pedicularis	24	11
Epilobium	23	11
Galium	23	11
Dracocephalum nutans	22	11
Nepeta	22	11
Polygognum cognatum	21	10
Saxifraga	20	10
Carex	19	9
Leontopodium	19	9
Primula	17	8
Bistorta	16	8
Eritrichium canum	15	7
Myosotis	15	7
Kobresia	14	7
Oryzopsis	12	6
Dichodon cerastoides	10	5
Arenaria serpyllifolia	9	4
Euphorbia	9	4
Arabis	8	4

Saussurea	8	4
Lindelofia anchusoides	7	3
Psychrogeton.	7	3
Rhodiola	7	3
Rosa webbiana	7	3
Spergularia rubra	7	3
Crepis	6	3
Gentiana	6	3
Hylotelephium ewersii	6	3
Silene vulgaris	6	3
Tanacetum	6	3
Androsace aizoon	5	2
Aster flaccidus	5	2
Festuca	5	2
Thalictrum	5	2
Youngia glauca	5	2
Cynoglossum	4	2
Lactuca	4	2
Poa	4	2
Arabidopsis	3	1
Capsella bursa-pastoris	3	1
Cherophyllum	3	1
Crucihimalaya	3	1
Cystopteris	3	1
Dianthus angulatus	3	1
Elymus	3	1
Fragaria	3	1
Prunella vulgaris	3	1
Scrophularia	3	1
Verbascum thapsus	3	1
Berberis pachycantha	2	1
Bergenia stracheyi	2	1
Corydalis crassifolia	2	1
Cotoneaster integerrimus	2	1
Gentianella moorcroftiana	2	1
Inula rhizocephela	2	1
Juniperus	2	1
Lagotis	2	1
Lonicera	2	1
Prangos	2	1
Salix denticulata	2	1

Viola	2	1
Aconogonon	1	0
Anemone rupicola	1	0
Cicer microphyllum	1	0
Codonopsis clematidea	1	0
Jaeschkea oligosperma	1	0
Plantago major	1	0
Pleurospermum spp	1	0
Rubus	1	0
Trachadaym	1	0
Tragopogon	1	0
Trigonella	1	0
Jurinea	0	0
Total	80	0

4.3.2. Plant communities in western Ladakh

Nineteen plant communities were segregated by using TWINSPAN along elevation range of 3700 – 4200 m.

***Epilobium – Rumex – Tanacetum* community:** This community was present across varying level of livestock grazing in the region. *Tanacetum* was absent in high grazing areas. It could be probably, due to its limited grazing resilience compared to other two species. Presence of *Rumex patentia* in high abundance in highly grazed areas could be due to adaptations to sustain grazing pressure.

***Androsace – Gentianella – Inula* plant community:** This community was found in moist and heavily grazed areas. Presence of *Gentianella* all the levels of grazing intensity could be due to adaptability to survive in harsh arid environments.

***Corydalis crassiflolia* community:** This formed a monotypic community in the valley. It was present in all levels of grazing. It is a resilient to livestock grazing and adapted to survive in trampled areas.

***Dracocephalum - Myosotis – Rhodiola* community:** This community was present in only low and moderate level of grazing intensity. Species in this class mostly inhabit shady slopes and perhaps rocky and skeletal soil could have attribute to low vegetation cover.

***Peduculiaris biflora* community:** This community was found in the valleys moist meadows, where there was high grazing intensity. It was present in 11% of the total quadrats sampled in the area.

***Fragaria - Sibbaldia – Veronica* plant community:** This community type was present in all grazing areas. *Sibbaldia cuneata* was also the most occurring species in the rangelands.

***Prunella – Trifolium* community:** This plant community was also present in all grazing levels of livestock pressure. The presence of *Trifolium* in high grazing areas could be attribute to its vast distribution, despite its high palatability. Besides, it occurred in 15 percent of quadrats in the region.

***Cynoglossum - Oxytropis – Silene* community:** This community was also present in all grazing areas. *Oxytropis* species a preferred diet of marmot and livestock, was present in high grazing areas also. Besides it occurred in about 15 percent of the quadrats

***Arabis – Ranunculus* community:** This community was also present in all grazing areas. Except that *Ranunuclus* in high and arabis in medium grazing areas were absent. The absence of *Ranunculus* in this area could be its preference by livestock in the region due to its high palatability.

***Crepis - Scrophularia – Lentopodium* community:** This community was also present in all grazing areas. Lentopodium is a preferred species by marmots.

***Anaphalis - Oxyria – Polygonum*, community**: This community was also present in all the grazing areas. Besides, *Anaphalis* species is preferred plant by marmot. It occurred in more than 30 % of the quadrats assessed for species presence in the region.

***Astragalus - Lactuca – Viola* community:** This community was also present in all the grazing areas. Besides, *Astragalus* species is preferred plant by marmot. It occurred in more than 26 % of the quadrats assessed for species presence in the region

***Eritrichium - Geranium – Thymus* community:** This community was also present in all the grazing areas. Besides, *Geranium* species occurred in more than 20 % of the quadrats assessed for species presence in the region

***Bistorta - Potentilla – Saxifraga* community:** This community was also present in all the grazing areas. Besides, *Potentilla and Saxifraga* species occurred in more than 35 and 10 % of the quadrats assessed for species presence in the region. Moreover, *Potentilla* is a preferred specie by marmots and livestock too.

***Primula denticulata* community:** This community was also present in all the grazing areas. Besides, *Primula* species occurred in 8 % of the quadrats assessed for species presence in the region. *Primula* is reportedly the most preferred specie by marmots.

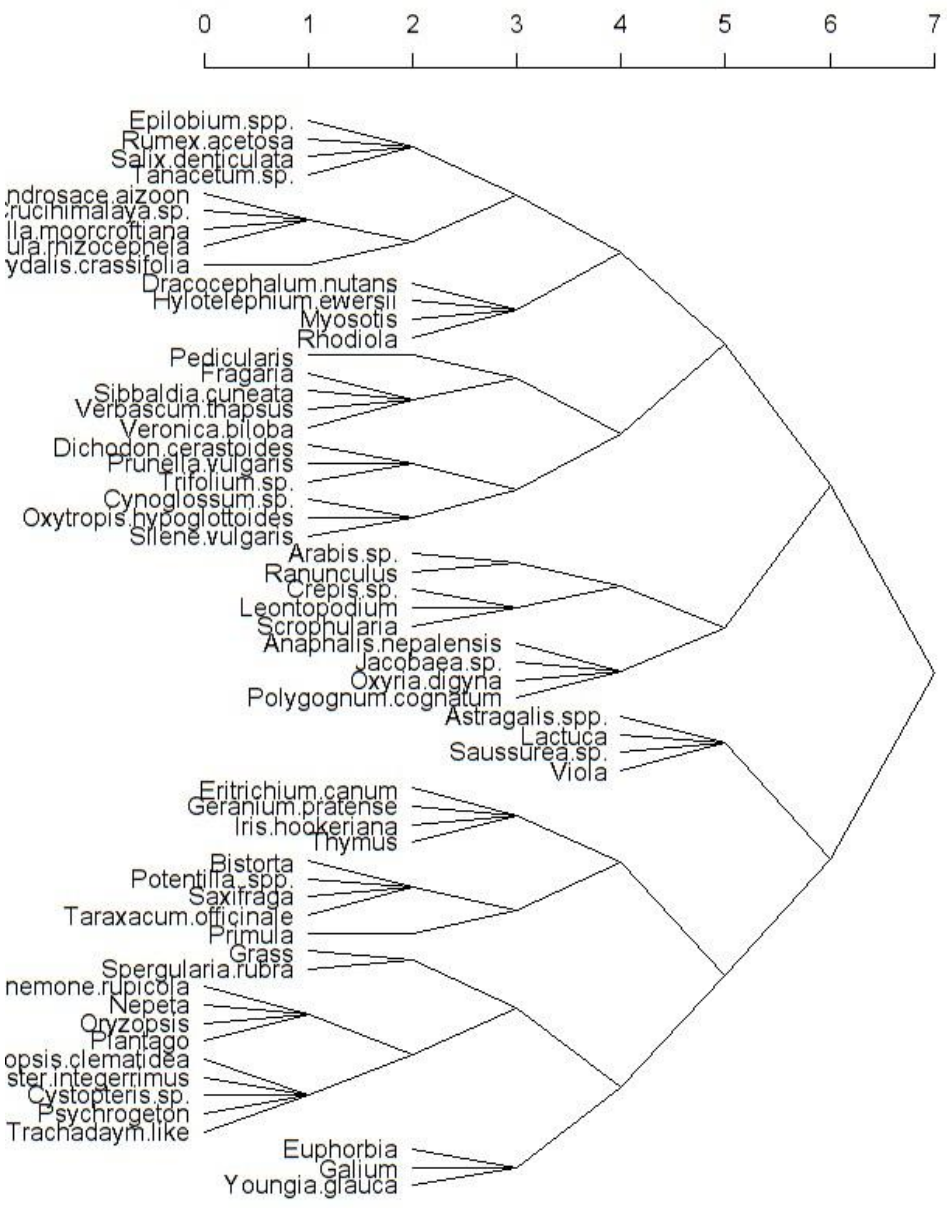
***Poa – Spergularia* community:** This community was also present in all the grazing areas. Grasses occurred in > 20 % of the quadrats assessed for species presence in the region. Grass species as *Poa* and *Carex* are reportedly preferred by marmots also.

***Anemone - Oryzopsis – Plantago* community:** This community was also present in all the grazing areas. Grasses occurred in > 20 % of the quadrats assessed for species presence in the region. Grass species as *Poa* and *Carex* are reportedly preferred by marmots also. Moreover, *Anemone* and *Plantigo* species were absent in high grazing areas of the region.

***Codonopisis- Psychoregeton – Trachydium* plant community:** This community was present in only low grazing areas of the region. Further, except for *Psychoregeton* which occurred in 3% of the quadrats the occurrence of Codonopsis and *Trachydium* were negligible.

4.3.2.19. *Euphorbia - Galium – Youngia* community: This community was present in all levels of grazing intensity areas. *Gallium* occurred in 11% of the quadrats, *Euphorbia* 4% and *Youngia* 2% of the quadrats.

Figure 4.1: Dendogram representing different plant communities in western Ladakh



4.3.3. Species richness and vegetation cover in western Ladakh

4.3.3.1. Species richness and vegetation cover

Overall, species richness per plot ranged from 3 – 14 species per plot, varying significantly across grazing intensities significantly ($F = 47.848$, $df = 244$, $P < 0.001$). Low grazing areas had the highest species richness (3 – 14), followed by medium (3 – 12), and high (3 - 9) species. Moreover, post – hoc multiple comparison test on mean species number, revealed that both low and medium grazing intensity areas have significant higher species richness in comparison to high grazing intensity areas (Table 4.4). Similarly, overall percent vegetation cover in the valley was 60% per plot. It varied significantly ($F = 18.009$, $df = 244$, $P < 0.001$), being highest in low and medium grazing areas (67%) and lowest in high grazing areas (48%; Figure 4.2).

Table 4.4: Species richness across different level of grazing intensity in western Ladakh

		Species			Significance level
Gradient	**Livestock**	Maximum	Mean	Minimum	$p < 0.05$
Low	300	14	8	3	$p < 0.05$
Medium	700	12	7	3	$p < 0.05$
High	2500	9	5	3	$P > 0.05$

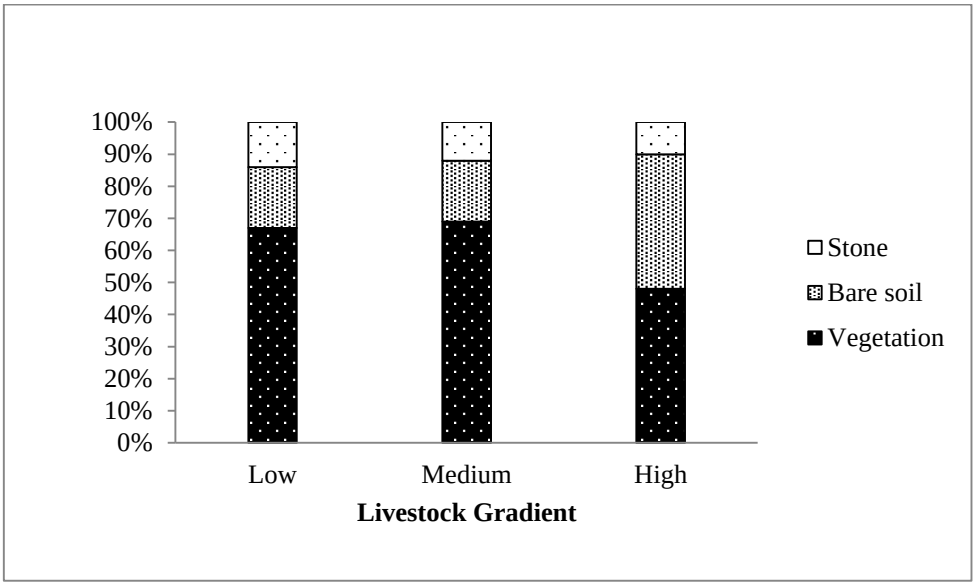


Figure 4.2: Variation in percent ground cover in a gradient of livestock population in the rangeland of western Ladakh

4.3.3.2. S**pecies richness and vegetation cover in different aspects types**

We observed variation in mean species richness and vegetation cover with respect to aspect in the region. Overall percent cover was highest in east aspect (68%) and least in south aspect (43%). In low grazing intensity areas it was highest in north – west aspect (80) and least in all southern aspect (59%). Likewise in medium grazing areas cover was highest in north – west aspect (81%) and least on south aspect (49%). In high grazing areas cover was highest in east aspect (71%) and least in south west aspect (30%; Table 4.5). Similarly, species richness was highest in north aspect (10) and least on south aspect (6). In low grazing areas species richness was highest in north – east (8) and north – west aspect (8) and least in south west (6) and east aspect (6). Species richness in medium grazing ranged from (7 – 8) in most of the aspect types. However

in high grazing areas species richness ranged from (5 -6) in most aspect types, with lowest in south aspect (Table 4.5).

4.3.3.2. Species richness and vegetation cover in different elevation levels

Overall, vegetation cover and richness remains comparatively similar with increase in elevation in low and medium grazing areas. However, it decreased with increase in elevation in high grazing areas (Table 4.5)

4.3.3.2. Species richness and vegetation cover in different slopes

We found decrease in vegetation cover with increase in slope in the valley. Overall vegetation cover decreased from 70% in slope < 10^{o} to 54 in slope > 35^{o}. Similar pattern of relative decrease in vegetation cover with increase in slope was observed in all level of grazing intensity. However, species richness remains comparatively same in all levels of grazing intensity (Table 4.5).

4.3.3.2. Species richness and vegetation cover in different landscape types

Vegetation cover in alpine meadows decreased from 70% in low grazing areas to 52 in high grazing areas likewise species richness decrease from 8 in low to 5 in low grazing areas. Similarly, in scree slopes vegetation cover decreased from 50 in low grazing area to 42% in high grazing areas. Similar decrease was observed in species richness, six in low to 4 in high grazing areas (Table 4.5).

Table 4.5: Vegetation cover and species richness in relation to biotic and abiotic factors in western Ladakh

	Overall		Low grazing		Medium Grazing		High grazing	
Aspect	**Vegetation cover**	**Species richness**	**Vegetation cover**	**Species richness**	**Vegetation cover**	**Species richness**	**Vegetation cover**	**Species richness**
East	68	7	59	6	75	7	71	6
North	62	10	60	7	67	7	60	6
North east	59	7	56	8	76	8	52	5
North west	65	6	80	8	81	7	50	5
South	43	6	59	7	49	7	34	4
South east	57	7	59	6	68	8	50	5
South west	54	7	59	7	56	8	30	6
West	61	7	63	7	56	8	53	5
Elevation								
3001-3400	55	6	61	8	-	-	51	5
3401-3800	55	7	55	8	60	7	55	5
3801-4200	60	6	65	7	66	7	39	4
Slope								
<10	70	7	75	8	75	7	56	4
11-35	60	6	64	7	70	7	48	4
>35	54	6	58	7	55	7	50	5
Landscape types								
Alpine Meadow	63	7	70	8	71	8	52	5
Scree Slope	48	6	50	6	55	7	42	4

4.4. Discussion

4.4.1. Vegetation composition in relation to grazing intensity

A total of 125 species distributed across various families and growth forms are reported from the valley. Asteraceae was the dominant family in the valley with preponderance of hemicryptophyte life and herbaceous/perennial life forms. Similar prevalence of Asteraceae family with significantly higher representation of hemicryptophytes are also reported by (Kala, 2011) in Ladakh and in Changthang region (eastern Ladakh) by Rawat & Adhikari, 2005 and Dvorskỳ et al., 2011. Significant dominance of hemicryptophyes in the valley could be attributes to their enhanced tolerance to withstand stress and arid cold climatic conditions. Further, presence of more grass species in high grazing areas indicates the effect of grazing on vegetation composition. Herbaceous flora were prominent in low grazing areas whereas grass presence were very less.

Nevertheless, our findings highlights the impact of grazing intensities on species richness and vegetation composition in alpine rangelands of western Ladakh. We observed that species richness and vegetation cover were highest in low and medium level grazing areas compared to high grazing areas. This difference in vegetation dynamics across different level of grazing signifies the detrimental effect of grazing pressure in the valley. Similar, vegetation dynamics in relation to livestock grazing are also reported by Namgail et al. (2012) in Ladakh.

Chapter 5: Habitat use and time budget of long tailed Marmots (*Marmota caudata*) in different livestock grazing intensity areas of Kargil, Ladakh

5.1. Introduction

Ladakh in Indian Trans Himalaya is characterised by extreme weather conditions, low primary product (Rawat and Adhakari, 2005) and heterogeneous topography with flat lands at low lying or elevated positions gradually traversing to steep rugged terrains (Fox et al., 1994). Mixed farming is the primary land use practice, where people use low lying areas and alluvial fans for agriculture, and pastures at higher elevations for animal husbandry. Moreover, livestock in these rangelands share the landscape with wild herbivores such as Asiatic ibex, Ladakh urial, musk deer and the long tailed marmot. Here livestock grazing is primary conservation issue as it affect habitat use, dietary habits and diurnal behavioural patterns of herbivores (Fox et al., 1994). Previous studies on the impact of livestock grazing on wild herbivores have highlighted direct disturbance and interference competition from livestock affecting habitat use, diet and time budget in species such as Tibetan gazelle (Bhatnagar et al., 2006; Namgail et al., 2008) and Tibetan argali (Namgail et al., 2007) in the region. Moreover, local perception of rise in kiang population, thus out competing livestock in forage utilization has resulted in conflict leading to fencing of most productive pastures (Bhatnagar et al., 2006). Such conflict has rendered use and accessibility of most productive pastures available for kiang and other wild herbivores (Bhatnagar et al., 2006) thus negatively affecting population of these species with high conservation values in these rangelands. Likewise, small mammals such as pikas *Ochotona spp.*,

voles *Alticola spp.* and marmot *Marmota sp.* species despite their role in sustaining rangelands health (Bagchi et al., 2006) are also perceived as threat to livestock by pastoralists leading to their eradication in most of their distribution limits. Moreover, areas used by long tailed marmots are also most favoured by pastoralists for livestock grazing due to their relatively higher productivity.

Long tailed marmots *Marmota caudata* are colonial ground dwelling mammals mostly inhabiting productive rangelands dominated by herbaceous meadows with widespread distribution in high altitude rangelands of Asia (India, China, Afghanistan and Pakistan) and central Asian countries (Molur et al., 2005). Marmots is an important indicator species of rangelands health with significant role in shaping vegetation structure seed dispersal, soil composition and overall ecosystem dynamics of the rangelands (Valkó et al., 2021). Besides, they are important prey species of carnivores such as snow leopard and the Himalayan brown bear (Aryal et al., 2015). The species is listed as near threatened in IUCN red list of threatened species and major threats includes overgrazing by livestock, conversion of lands for agriculture, civil unrest and landslides (Molur et al., 2005). Notably, marmots comes in direct contact livestock due to preference of productive pasture, where the species inhabit, by the herders for livestock grazing. Likewise, grazing transform vegetation, induces graminoid dominance and leads to the near or complete extinction of certain plant types such as tall forbs, subshrubs without thorns or secondary compounds, and annual herbs (Rawat & Adhikari, 2006). Yet, studies in Mongolia have found marmots and livestock co – occurring in alpine rangelands (Salvatori et al., 2022) creating synergic effect on the ecosystem at moderate grazing intensity in addition to benefitting marmot population

(Gankhuyag et al., 2021). In Altati mountains, Russain federation also, no affect of livestock on marmots habitat preferecne were observed (Řičánková et al., 2014). Aditionally, marmots in North-Western Italian Alps were found less vigilant in open areas which enhances their visibility of predators (Ferrari et al., 2009). Similarly, livestock could also facilitate marmots by reducing grass height and enhancing visibility of predator thus reducing its vigilance behaviour. Yet studies have highlighted intensity of livestock grazing affecting diurnal behaviour of marmots particularly causing temporal shift in its activity and increased vigilance (Poudel et al., 2015). Although, group sizes in marmots colonies were kept similar in this study.

In this study, we examined effects of livestock grazing intensities on habitat use by long tailed marmots in western Ladakh (Image 5.1). Besides, we assessed the effect of livestock presence and group size on time budget of the species in the area. Overall, we expected decreased population of marmots and to increased vigilance behaviour in relation to grazing intensity and livestock presence.

Image 5.1: Long tailed marmot in a highly grazed area in the study region

5.2. Data analysis

5.2.1. Logistic regression analysis and variables used predict rangeland use by long tailed marmot

In order to establish most important biotic and abiotic factors we included factor as aspect, climatic moisture index, elevation, rangelands and barren lands to assess the most important factor governing marmot use of rangelands. The logistics regression model (GLM) used was:-

$$\text{logit}(P) = \beta_0 + \beta_1 \text{Aspect} + \beta_2 \text{Barrenland} + \beta_3 \text{CMI} + \beta_4 \text{Elevation} + \beta_5 \text{Rangelands}$$

P is the probability of presence whereas βs are the coefficients estimated by the model. The best model with lowest AIC values were used to interpret the model result.

We used "glm" function in R- studio (RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

5.2.2. Proportionate difference in habitat use and time budget

In order to establish variation in rangeland use by marmots and to establish difference in relation to livestock grazing, we used proportionate estimate of marmot population with respect to grazing intensity. Marmot population in low, medium and high grazing intensity were compared in relation to aspect, slope angle, position, elevation, landscape types and position at different elevations.

Likewise, proportionate time spent in foraging and grazing were compared with respect to livestock presence and group size.

5.3. Results

5.3.1. Habitat use by long tailed marmot

A total of 787 individual were recorded in the study area. This comprised of 263 individual in high followed by 275 in medium and 249 in low livestock grazing intensity areas. The encounter rates per kilometre were almost comparable in all the areas with 15 individual per Km in High, 13 individual in medium and 12 individual per km in low livestock grazing intensity areas. Likewise, overall group size in the species ranged from 5 – 24 individuals. Group size were 5 – 22 individuals in high, 5 – 24 individual in medium and 5 – 21 individuals in low grazing intensity areas. Marmots were found in the elevation ranging from 3000 m to 4600 m, with maximum number (411) at elevation between 3800 m – 4200 m. GLM also predicted similar result with significant number preferring higher elevations. Besides, this pattern was also observed in elevation use of marmot at local scale in a valley and at regional scale also (Figure 5.1).

Table 5.1: Variation in marmot number in elevation ranges and across different level of grazing intensity in western Ladakh

Altitude	Overall	Local Increase	Gradual Increase	High	Medium	Low
<3000	0	0	0	0	0	0
3001-3400	207	73	30	93	0	11
3401-3800	117	107	10	56	43	28
3801-4200	411	249	157	17	121	100
4201-4600	52	0	52	0	0	21
>4600	0	0	0	0	0	0

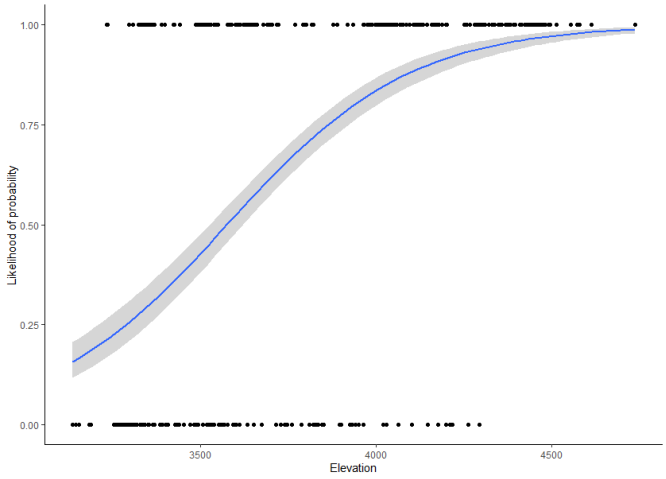


Figure 5.1: Livelihood of probability in use of elevation by marmots western Ladakh

Besides in terms of use of position at different elevations, we observed marmots at all positions. However, maximum number of marmots were observed using lower position followed by bottom, middle and upper. Minimum number of marmots were found using top positions in elevation limits (Table 5.2).

Table 5.2: Variation in marmot number in different position levels across different level of grazing intensity in western Ladakh

Position	Overall	High	Medium	Low
Bottom	168	56	56	56
Lower	255	95	12	148
Middle	170	112	22	36
Upper	153	0	150	3
Top	41	0	35	6

Likewise, in terms of slope angle use marmots were found in all slopes angles ranging from 0 -50^{o}. No observations were made in slope angle exceeding 50 degrees. Overall, based on field observations we found maximum number of individual sighted at intermediate slope angle 21 – 30^{o}. However, the model did not showed significant

difference in marmot usage pattern with respect to variation in slope angle. Maximum usage of intermediate slope by marmots were also observed in both high and low livestock grazing intensity areas (Table 5.3).

Table 5.3: Variation use of slope angles by marmot across different level of grazing intensity in western Ladakh

Slope	Overall	High	Medium	Low
0	100	15	35	50
<10	71	12	9	50
>10-20	223	65	110	48
21-30	238	95	81	64
31-40	121	54	28	32
>40	34	22	12	5

Similarly, marmots were omnipresent in all aspects with maximum individuals recorded in southern aspect (SE and SW combined) followed by northern aspect (NW & NE combined) and the least in western aspect (Table 5.4). This was consistent with our model prediction (Figure 5.2). Although, we observed discrepancies in marmot aspect usage in high and low grazing intensity areas. Marmots in high use areas were maximum in north aspect whereas in low use areas marmots were in maximum number in southern aspect (Table 5.4).

Table 5.4: Variation use of aspects by marmot across different level of grazing intensity in western Ladakh

Aspect	Overall	High	Medium	Low
Flat	138	15	66	57
North	207	112	64	31
South	266	68	79	119
East	90	40	45	5
West	86	28	21	37

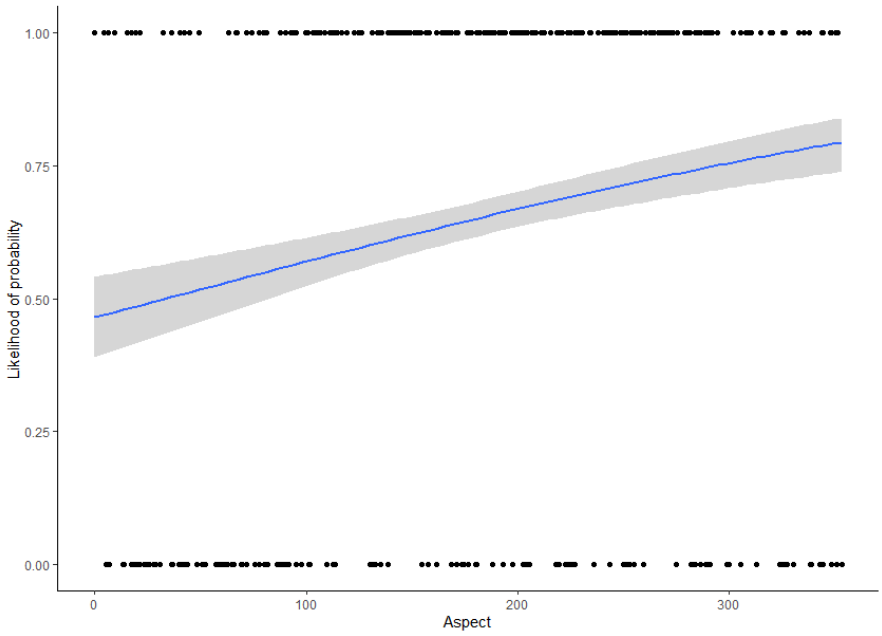


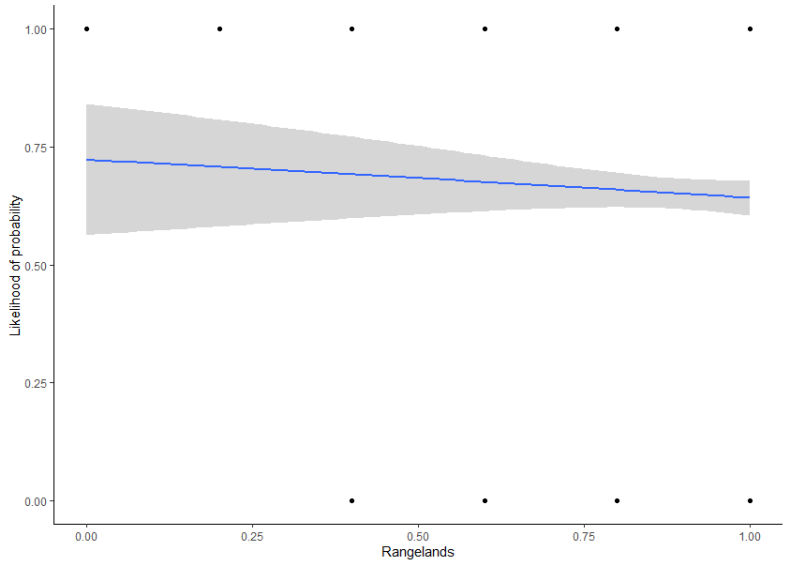
Figure 5.2: Livelihood of probability in use of aspects by marmot across different level of grazing intensity in western Ladakh

Nonetheless, we observed marmots preferring alpine meadows landscape types with boulders and rocks the most, followed by scree slopes. They were least observed in marshy and agriculture fallow landscape types in the region (Table 5.5). Similar prediction on usage of landscape type were also revealed by the model (Figure 5.3). However, based on the model prediction we presume that marmots are unlikely to be found in areas with woody vegetation and increased plant height. This pattern of landscape type's usage was also found in high and low livestock use areas also.

Table 5.5: Variation use of landscape types by marmot across different level of grazing intensity in western Ladakh

Landscape types	Overall	High	Medium	Low
Agri Fallow	4	0	0	4
Alpine Meadow	502	183	153	166
Marshes	21	0	0	21
Scree Slope	260	80	122	58

a



b

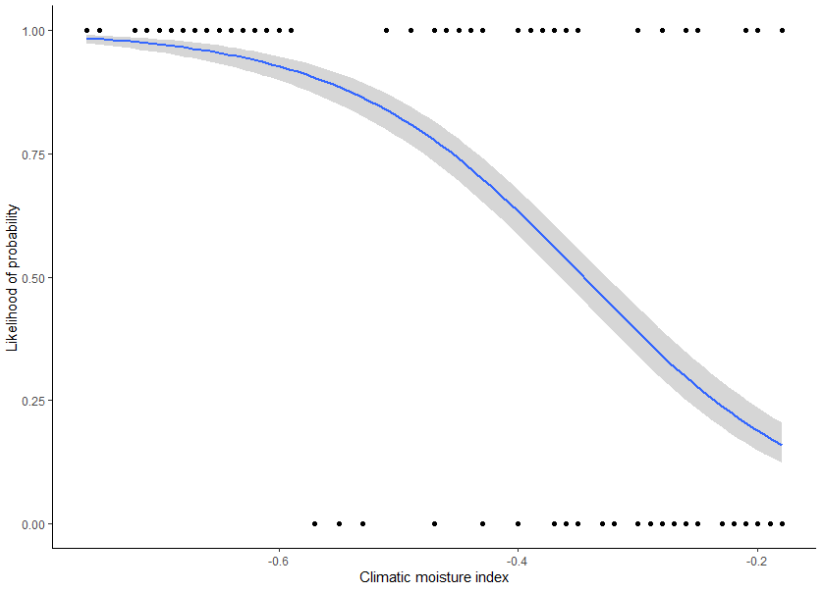


Figure 5.3: Probability of livelihood in use of rangelands with respect to vegetation density (a) and climate moisture index (b) in western Ladakh

5.3.2. Time Budget and group size effect in long tailed marmot

We did not observed much variation in habitat use by marmot in relation to livestock use intensity, except for difference in usage of aspects in high and low livestock use areas. Therefore, we compared difference in time budget; vigilance and foraging behaviour of marmots in relation to group size and its distance from livestock in the region. Overall, focal animal sampling for 240 minutes on marmots in 21 colonies comprising 120 individuals revealed that marmots spent 84% of time in foraging while 16% time in vigilance. Likewise, marmot (8 colonies; 86 individuals) sampled for 78 minutes in the presence of livestock at distance less than 100 metres spent 83% time foraging and 17% time in vigilance. Whereas, marmot (14; 149) sampled for 162 minutes in absence of livestock spent 85% time foraging and 15% time in vigilance. However, marmots (5;99) sampled for 52 minutes in group size > 14 individuals spent 88% time foraging and 12% time in vigilance whereas, marmots (9;44) sampled for 52 minutes in group size <7 individuals spent 77% time foraging compared to 23% in vigilance (see, Figure 5.4)

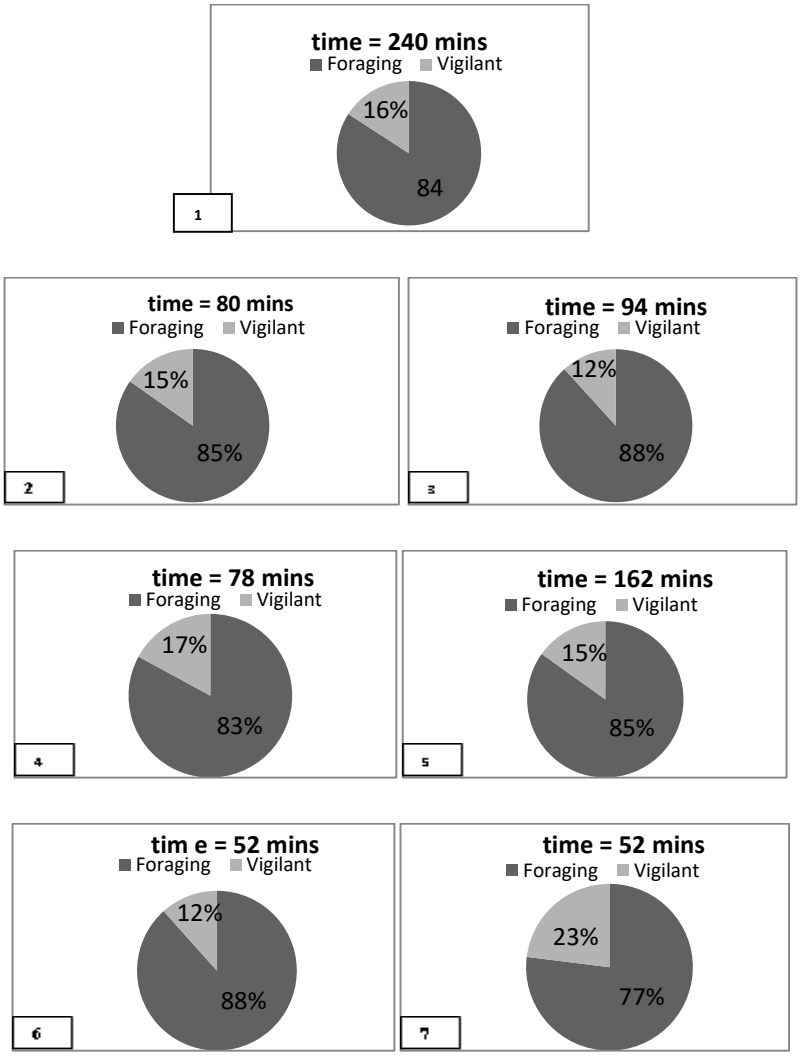


Figure 5.4: Difference in foraging and vigilance behaviour of marmot, 1; overall difference in foraging and vigilance of marmots, 2; time budget in low livestock grazing intensity area, 3; time budget in high livestock intensity area, 4; time budget without livestock, 5; time budget with livestock distance <100 metres from marmot, 6; time budget of marmot with group size ranging from (3-7) individuals and 7; time budget with group size ranging from (14-25) individuals.

5.4. Discussion

5.4.1. Habitat preferences in long tailed marmots

We found marmot in western Ladakh exhibiting relatively stable habitat use pattern across varying level of livestock grazing intensities. The similar encounter rate and consistent group size in high, medium and low grazing intensities also suggests that marmots have remarkable adaptability to varying grazing pressures and can co-exist with livestock to a certain extent. This corroborates with similar finding in other marmot species such as Yellow bellied marmot, which also exhibits flexibility in habitat use in varying level of grazing intensities and human pressure. Similar level of resilience signifying co-existence between marmots and livestock creating a synergic effect on the ecosystem were also observed by (Gankhuyag et al., 2021; Salvatori et al., 2022) in Mongolia. Further, the existence of marmots despite grazing pressures might be attributed to its generalist foraging habits and ability to exploit different habitat types. But this need to be assessed in long tailed marmot by undertaking a study on its dietary and feeding habits. Additionally, the stable group size across grazing intensities further reinforces this adaptability in marmots, indicating that they can maintain their social structure despite grazing pressures(Zhou et al., 2021). Nonetheless, their preferences and discrepancies in usage of different physical parameters such as aspect, position and landscape type, highlights their need for micro – habitats that provide optimal conditions for burrow construction, foraging and protection from predators.

Overall, our GLM results indicated preference for higher elevation in marmots and is consistent with their known ecological requirements (Bhardwaj et al., 2023). However,

their presence in maximum number at mid elevation between 3800 to 4800 meters, lower positions and intermediate slope angles (20 - 30) may be attributed to the temperature differences, availability of suitable burrowing and foraging sites (Wang & Hou, 2021). Temperature at higher elevation are cold and vice versa, and perhaps marmots prefer mid elevation to align with its thermoregulatory conditions which is critical for its survival and reproductive success (Herrero et al., 1994). Likewise, lower positions typically have higher vegetation richness due to better moisture retention, which supports the marmot foraging needs. Additionally, intermediate slope might offer a compromise between drainage and soil stability, facilitating both foraging and burrow construction in marmots (Wang & Hou, 2021). Such finding indicate that their preference of elevation, slope and position are primarily driven by environmental and geomorphological factors rather than livestock grazing (Řičánková et al., 2014). Furthermore, the preference of alpine meadows with boulders and rocks, as predicted by the GLM, emphasizes the importance of environmental factor rather that disturbance regimes in habitat selection of marmots (Ballová & Šibík, 2015). Such areas offers abundant forage in addition to suitable substrates for burrowing that are primary and crucial for marmot survival and reproduction. The model also predicted avoidance of marshes and areas dense with tall vegetation such as agriculture fallow indicating their requirement of open habitats that facilitates vigilance and predator detection in marmots (Chmura et al., 2016; Guo et al., 2020; Wang & Hou, 2021)

Pertinently, the most important factor determining habitat use pattern in marmot based on field observations and GLM prediction was its selection in aspects. Overall, we observed preference of southern (SE and SW combined) and northern aspects (NE and

NW combined) in the study area. Such preferences in marmots maybe linked to its thermoregulatory requirement and feeding requirements(Wang & Hou, 2021; Ferrari et al., 2022). Southern aspect receive more sunlight which is a prerequisite for its thermoregulation. Besides, higher exposure to sun affect snow melt patterns, influencing the availability of vegetation during growing season in the southern aspect (Turnock et al., 2017). Similarly, its selection of northern aspect might be in search of refugee and cooler micro habitats to strike a balance in body temperature during hotter periods. This finding substantiates its preference of higher elevation which probably offers similar micro habitat and climatic conditions(Ferrari et al., 2022). However, the discrepancy in preference of aspects in high and low grazing intensities areas (northern aspects in high versus southern aspect in low) grazing intensities underscores adaptability in marmots to environmental conditions influenced by livestock grazing. Probably, livestock grazing influences soil stability which are important factor in burrow site selection in marmots. Besides trampling of vegetation by livestock might lead to runoff of water in burrows besides affecting micro habitat condition in these areas.

5.4.2. Livestock presence and vigilance behaviour in marmots

The findings on time budget analysis reveals that marmots spent most of the time foraging than vigilance. This is consistent with its primary biological requirement reported by Armitage et al., (1996). Moreover, this balance changes slightly in the presence of livestock (<100 meters), with vigilance increasing; indicating alertness due to potential disturbances such as shepherd dogs (Poudel et al., 2015). This also indicative that livestock grazing would influence natural anti predator behaviour of

marmots thus affecting its survival and reproduction (Li et al., 2011). Overall, marmots exhibited difference in vigilance behaviour between large (>14 individuals) and small (<7) groups. Smaller groups showed higher vigilance in comparison to larger groups. This finds aligns with similar studies on marmots (*Marmota marmota*) in North-Western Italian Alps (Ferrari et al., 2009) and underscores the importance of social structure in risk management and predator detection in marmots(Holmes, 1984; Armitage et al., 1996; Ferrari et al., 2009). Larger groups can afford allocating more time in foraging than vigilance due to shared risk and predation detection responsibilities, thus enhancing foraging efficiency and overall fitness in marmots (Armitage et al., 1996) .

5.4.3. Vegetation vs. marmot presence

We observed marmots preferring northern aspects in high grazing intensity whereas it preferred southern aspect in low and medium grazing intensity areas. Thus, we emphasise that marmots avoid high grazing intensity areas due to lower vegetation cover. Preference of northern aspect could be an adaptation strategy in marmots as often due to vegetation trampling by livestock and higher exposure to sun, surface soil loses its intactness leading to runoff in burrows. Further, increase in species richness with elevation supports our argument of marmot presence in maximum number at higher elevation due to availability of foraging habitat. Perhaps, lack of vegetation cover is compensated by increase in species richness at higher elevation, thus supporting higher marmot population

5.5. Conclusions

The long tailed marmot in the rangelands of western Ladakh exhibit much adaptability in habitat use in presence livestock. They co exists with marmots and show resilience to grazing intensities in their habitat use pattern. Besides our results indicates that their habitat use patterns are determined by environmental and geomorphological factors which affects micro habitat conditions. Overall, the most important factor determining marmot habitat use are aspect and elevation in addition to slope angle. Underscoring the effect of temperature and geomorphology on their habitat selection. Moreover, marmot physiology is highly adapted to coping with low environmental temperatures but are stressed by high environmental temperatures leading to infant mortality (Armitage, 2013; Galluzzi et al., 2017). Besides, studies indicates rising temperature in the study area on account of climate change (Koul et al., 2016). Additionally, local also perceive increase in temperatures and changing weather regimes with less snow in winter and erratic rainfall in summers. Therefore, we recommend understanding climate change effect on marmot habitat selection in future research it is necessary to with focus on local weather regimes, including snowpack and marmot food sources in addition to their reproductive biology and survival rates. Additionally, it is important to understand effect of livestock on soil stability and status of meadows and its mapping to verify weather selection of northern aspects by marmots in high grazing areas are an adaptation to grazing intensities or a selection by chance on account of nutritious plants and suitable microhabitats.

Chapter 6: Livestock killing by large carnivores in Kargil, Indian Trans – Himalayas: pattern and people's perceptions

6.1 Introduction

Carnivore caused livestock mortality and consequent economic loss dates back to medieval times when humans started domesticating livestock (Anand & Radhakrishna, 2017). It is considered a serious global problem, as affected farmers resort to retaliatory killing(Treves & Karanth, 2003; Karamanlidis et al., 2011; Carter & Linnell, 2016). Such actions result in extermination of carnivores from certain areas, as observed in case of wolves *Canis lupus* in Northern America (Musiani & Paquet, 2004; Chavez & Gese, 2005), bears *Ursus arctos* in Europe (Zedrosser et al., 2011)and lions *Panthera leo* and spotted hyenas *Crocuta crocuta* in Africa(Holmern et al., 2007). The issue of human – carnivore conflict in the Indian Sub-Continent, which has an agrarian economy, is very acute. Anand and Radhakrishna (2017) found nearly 90 % of inhabited area in India affected by human – wildlife conflict. Several species such as snow leopard *Panthera uncia*, Tibetan wolf *Canis lupus chanko* and bears *Ursus arctos isabellinus* face similar threats of persecution in retaliation of livestock killing (Habib et al., 2013; Bargali, 2012; Jackson & Wangchuk, 2004)

Investigating trend of human – wildlife conflict (HWC) in India, Anand and Radhakrishna (2017) reported over 69% conflict occurring outside protected areas whereas only 31% of conflict is reported form PA. Such increase in livestock predation by large carnivores outside protected areas has been attributed to increase in their population due to strict carnivore protection laws (Wang & Macdonald, 2006; Treves

et al., 2004). But predation on livestock is predicted to increase if natural prey species population is low and access to alternate prey species such as livestock is easy (Bereczky et al., 2012). Moreover, misidentification of underplaying threats such as disease and political factors in addition to inconsistent and sparse data on HWC make this problem more complex(Carter et al., 2012; Dar et al., 2009; Meriggi & Lovari, 1996)

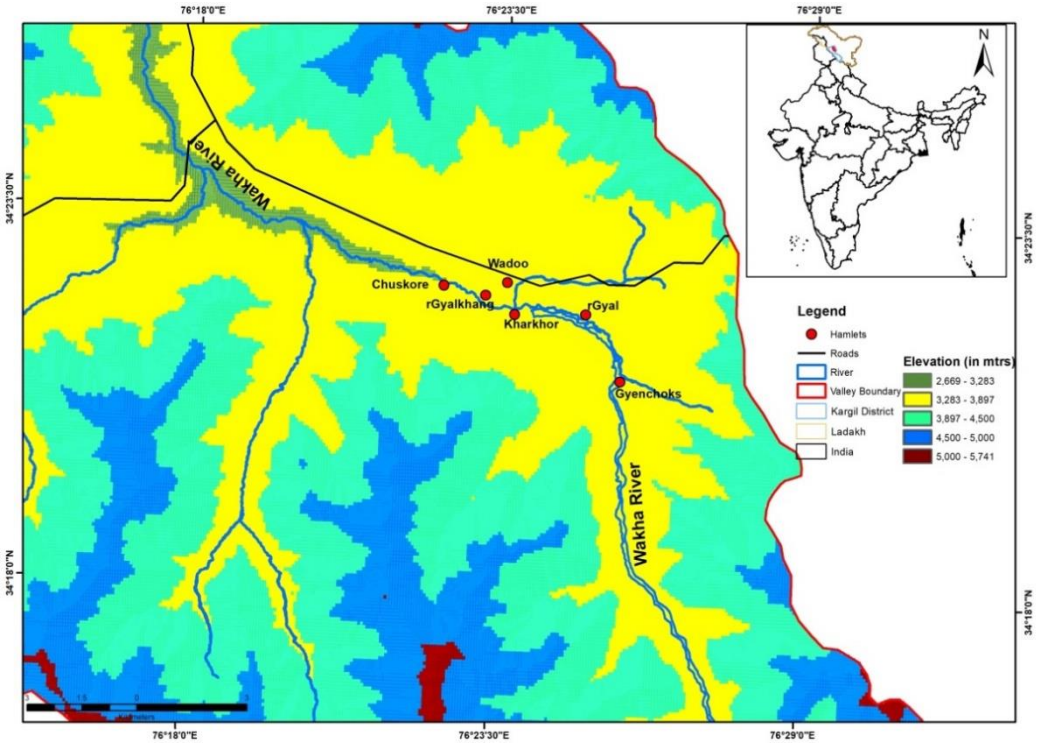
Ladakh in the Trans-Himalayas (TH) is a mosaic of different habitats where wild and domestic herbivores extensively share the same rangeland resources. Here predation on livestock by wild carnivores is a major conservation issue. Seven large carnivore species in the region are known to prey domestic livestock. Moreover irate farmers resort to retaliatory killing (Namgail et al., 2007; Mishra, 1997) yet scale of its occurrence on regional scale is not known. Heavy livestock mortality due to snow leopard *Panthera Uncia* in Indian Trans – Himalayas is reported from Spiti, Himachal Pradesh (HP) (Mishra, 1997), Gya – Miru area in Eastern Ladakh ((Namgail et al., 2007) and Hemis National Park in central Ladakh(Jackson & Wangchuk, 2004). In addition Tibetan wolf *Canis lupus chanko* and Eurasian lynx *Lynx l.isabellina* are also reported to kill livestock in these areas(Jamwal et al., 2019; Namgail et al., 2007).

In perspective data on human – wildlife conflict in Kargil is scarce and anecdotal despite reported presence of large carnivores such as Tibetan wolf, Eurasina lynx, snow leopard and Himalayan brown bear. People mentioned (Pers. Communications) livestock depredation by bear, wolf and snow leopard. Pertinently, they remember bear seldom killing livestock in ranges and never frequenting human dominated areas in the past but now it can be seen every day in the village they retort. Interestingly people identify two type of bears in the region; *Sha – den* (meat – eating) and *rTsoa – den*

(grass – eating). They recall *rTsoa – den* eats grass in close proximity to livestock groups. *Sha – den* which is rare often enter corrals at night, kill livestock and dismantle compound walls, roof tops, doors and windows. They also raid ration stores if they don't get livestock during their hunt people mentioned.

Jackson and Wangchuk (2004) attribute high livestock depredation by wild carnivores to poorly constructed livestock corrals (livestock sheds) and poor herding practices. However, our understanding of the underlying causes of intense human-wildlife conflict remains rudimentary, as most part of the Indian Trans-Himalaya remains unexplored. Therefore, we studied livestock depredation by large carnivores to understand the extent of human wildlife conflict in the Trans-Himalayan Mountains of Kargil, Western Ladakh (Image 6.1), where HWC remains virtually unexplored. We assessed 1) depredation of different livestock types in proportion to their availabilities, 2) spatio – temporal pattern of depredation to identify conflict hotspots and seasons 3) local peoples' perceptions of human-carnivore conflict.

Image 6.1: Map of hamlets surveyed in study area



6.2. Data analysis

6.2.1. Livestock population and depredation by carnivores

Population and depredation of each livestock was added for all households to estimate proportion of total livestock killed per household / year. Likewise, proportion of livestock type killed by each carnivore was estimated by dividing number of each livestock killed by the carnivore with total livestock killed. Similar proportions were calculated to estimate spatial and temporal pattern of livestock type killed by each carnivore. Data analysis for this part was conducted using, Microsoft Excel Statistics Calculator.

6.2.2. Prey selection by predators and comparison among livestock types

Selection of livestock types by carnivores was tested using modified chi-square test: log-likelihood chi-square test (Manly et al 1993). In case of rejection of the null hypothesis or no selection, Bonferroni-adjusted 95% confidence intervals were set to determine selective killing of livestock types by carnivores. A livestock was killed more than expected based on its relative abundance, if the lower confidence interval was greater than its population proportion. Whereas a livestock was killed less than expected if the upper confidence limit excluded its population proportion.

6.3 Results

6.3.1. Patterns of livestock depredation by large carnivores

Overall, eighty households owned 1437 livestock giving an average herd size of 18 livestock per household. Most of the household (n=76 or 95%) owned cow followed by sheep/goat (51 or 64%). Dzo/dzomo (hybrid between yak and cow; here after dzo/mo) and donkey were owned by (32 or 40%) and (29 or 36%) households respectively. Sheep/goat (approx. 1088 or 76%) formed bulk of livestock population proportion whereas donkey (approx. 67 or 5%) proportionately has the smallest population (Table 6.1).

Table 6.1.: Livestock types and their proportionate losses in western Ladakh

Livestock Type	Population	Composition	Number Killed	pc Killed
Donkey	67	5	33	31
Cow	225	16	9	8
Dzo/mo	57	4	2	2
Sheep/goat	1088	76	63	58
Total	1437	100	107	100

The villagers incurred a total loss of 107 livestock heads or 7.44% of the total livestock population over a period of three year beginning in March 2013 to March 2016. This amounted to 2.48% livestock heads killed per year or 1.21 livestock head loss per household in the study area. Sheep/goat (63 or 58%) were the main victims followed by donkey (33 or 31%). Least damage occurred to cow and dzo/mo (Table 6.1).

Overall, Tibetan wolf was the most important predator accounting for 35 cases or 33% total loss, followed by bear (34 or 32%). Livestock lost to snow leopard and other predators were (22 or 21%) & (16 or 15%) respectively (Table 6.2).

Table 6.2: Major carnivores involved in livestock depredation in western Ladakh

Species	Brown bear	Snow leopard	Tibetan wolf	Others
Donkey	24	1	3	5
Cow	8	1	0	0
Dzo/mo	2	0	0	0
Sheep/goat	0	20	32	11
Total killed	34	22	35	16
% Killed	32	21	33	15

Different livestock types differed significantly in their vulnerability to predators. Donkey were killed significantly more than expected from their relative abundance (χ^2 = 116.017, df = 4, P > 0.05). Overall bear killed donkeys significantly more than expected (χ^2 = 138.523, df= 4, p <0.01) as the lower confidence interval for this livestock type was greater than its population proportion. Similarly snow leopard (χ^2 = 5.480, df= 4, p <0.01), Tibetan wolf (χ^2 = 15.883, df= 4, p <0.01) and others (χ^2 = 23.475, df= 4, p <0.01) killed goat significantly more than expected. However, other livestock types were killed in proportion to their relative abundance (Table 6.3).

Table 6.3: Livestock populations (proportions) killed by major carnivores along with Confidence intervals (95%) in western Ladakh

		Bear			Snow leopard			Wolf		
		Bonferroni confidence limits			Bonferroni confidence limits			Bonferroni confidence limits		
Livestock type	Pop. prop.* (n=1437)	Prop. killed	Lower	Upper	Prop. killed	Lower	Upper	Prop. killed	Lower	Upper
Donkey	0.047	0.706^{+}	0.606	0.806	0.045^{0}	0.041	0.050	0.086^{0}	0.080	0.100
Cow	0.157	0.235^{0}	0.160	0.310	0.045^{-}	0.041	0.050	0.000	0.000	0.000
Dzo/mo	0.040	0.059^{0}	0.052	0.066	0.000	0.000	0.000	0.000	0.000	0.000
Sheep	0.334	0.000	0.000	0.000	0.318^{0}	0.209	0.427	0.371^{0}	0.317	0.498
Goat	0.423	0.000	0.000	0.000	0.591^{0}	0.455	0.726	0.543^{0}	0.481	0.686

*Pop. =Population, Prop. = Proportion $^{+}$ = killed more than expected, $^{-}$ = killed less than expected, ^{0} = killed in proportion to abundance

Thirty six individuals (41 % of the people interviewed), were interviewed to find out peoples attitude towards large carnivore in the Valley. Of these, 32 or 89% respondents had negative attitude, which they attributed to livestock depredation or property damage by predators. Large number of respondents (n=27; 75%) ranked bear as the most problematic predator followed by snow leopard 7; 19%, and wolves 2; 6%. A majority of the respondents also reported a gradual rise of livestock killing by bear in recent times, perhaps due to pasture degradation.

Despite the high rate of livestock depredation and property loss in the Valley, nobody received any compensation. Those who applied for monetary compensation reported that complicated procedures of filing cases and minimal compensation, discouraged villagers from applying for it.

6.3.2 Spatial and temporal variation in livestock depredation

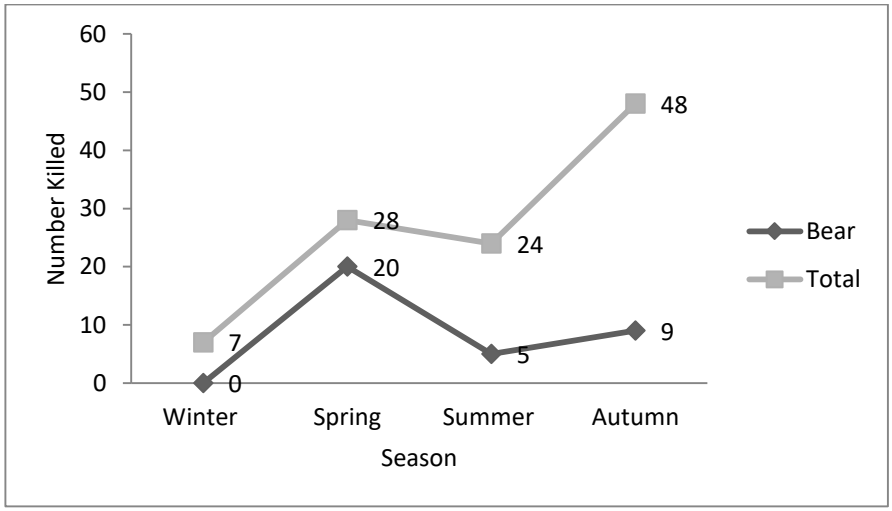
Out of the three zones, maximum livestock depredation occurred in Zone-1 (mountain cliff and opening of gorges; 54%), followed by Zone-2 (Valley bottom; 41%), followed by Zone-3 (areas away from mountain cliff and gorges; 5%). Out of 107 livestock killed, 70 (65%) were killed in open and the rest (37 or 35%) were lost inside corrals. Only bear and snow leopard attributed to livestock killing inside corrals with killing amounting to 19 or 51% livestock and 18 or 49% of their total killings respectively (Table 6.4). Additionally, depredations inside corrals were reported only at night.

Table 6.4: Spatial variation in livestock depredation by different carnivores in the western Ladakh

	Species				
Location	Brown bear	Snow leopard	Tibetan wolf	Others	Total
Corral	19	18	0	0	37
Open	15	4	35	16	70
Total	34	22	35	16	107

Pattern of livestock killing varied seasonally. Maximum number of depredation occurred in spring (n=28; 26%) followed by autumn (48; 45%), summer (24; 23% and winter (7; 6%). Tibetan wolf and snow leopard did not kill any livestock in winter season (January-March). Brown bear killed mostly in spring (20; 59%) followed by autumn (9; 26%) and the least (5; 15%) in summer (Figure 6.1). In addition to livestock depredation, bear dismantled roofs, destroyed compound walls and raided ration stores. During the study, two incidents of bear attacking humans, although non – fatal, were reported.

Figure 6.1: Seasonal variation in livestock depredation by large carnivores and bear in western Ladakh



6.5 Discussion

6.5.1 Livestock killing pattern by large carnivores

In terms of livestock depredation wolf was the most important predator followed by bear and snow leopard. Wolf killed sheep and goats but it never preyed on cattle. Such patterns of livestock killing by wolf were also reported from Himachal Pradesh (HP) by Mishra (1997) and by Namgail et al., (2007) in Gya – Miru, eastern Ladakh. High depredation by wolves are also reported from the Tibetan plateau (C. Li et al., 2015), Europe(Meriggi & Lovari, 1996) and North America(Muhly & Musiani, 2009).

Although the overall number of livestock killed by snow leopard was low, the number of livestock killed per incident was high. Such high losses were also reported from other parts of Ladakh (Namgail et al., 2007), Himachal Pradesh (Mishra, 1997) and Tibet (Li et al., 2013). Most of the livestock killed by the snow leopards were goats, largely because most of depredation occurred inside corrals that sheltered sheep and goats. Though predation by wolf and snow leopards were common, people distress increasing incidents of livestock depredation by bear in the recent years.

Brown bear killed donkey more than expected and rarely killed sheep and goats. A study by (Bargali, 2012) in Himalayas report livestock depredation by brown bear, although the types depredated were not verified. Livestock depredation by bear is also reported from Europe (Zimmermann et al., 2003), in China (Li et al, 2015) and Afghanistan (Moheb et al., 2012). In Afghanistan bear are reported to kill bulls only (Moheb et al, 2012).

Bears in the Valley, apart from livestock depredation, also dismantled farmers' property such as roof tops, corral doors, compound walls and windows. They also consumed stored food such as sugar, flour, rice, dal and ghee (clarified butter). Some

people also alleged that bears mix ghee and wheat. Such intrusions by brown bear into human habitations were also reported from Europe and North America (Karamanlidis et al., 2011) Some studies linked the surging human – bear conflict with increasing populations of bears and scarcity of natural resources (Fernández-Gil et al., 2016). Rather damage to property by brown bear increases if leftover food and garbage are not disposed of properly(Bereczky et al., 2012; Ambarli, 2016)

Furthermore, some natural prey species, such as the marmot hibernate for a longer period than bear, and this might have compelled bear to look for livestock to supplement their diet. Interestingly in Drass Valley in the extreme west of Ladakh, people attribute increase in human – bear conflict post year 1999 to improper management of leftover food in and around infantry units (Pers. Communication). Number of infantry unit in Drass increased after the 1999 war fought between India and Pakistan. They also mentioned increase sighting of brown bear thus its population; to artificial food availability and decreased pub mortality.

But Wakha Valley is located in a rural agro – pastoral area where leftover food is fed to livestock and army is absent. Thus, we could not link raiding ration stores by bear to poor food disposal method. Therefore we conclude that rise in bear conflict in the region is either linked to rise in bear population or scarcity of natural resources.

6.5.2 When and where did maximum depredation happened?

Livestock depredation differed across space and time. Wolf the most important predator killed livestock in open areas, snow leopard killed inside corrals whereas bear killed livestock in open as well as in corrals. This could be perhaps due to poorly constructed corrals and poor herding practice. More number of livestock were killed in areas close to cliffs and gorge openings. Thus, livestock are more vulnerable to

wolves when they graze in open areas, and they are more vulnerable to snow leopard and bear near cliffs and valley mouths. Thus, their herding practices need to be improved to prevent depredation by wolf, while the corrals need to be strengthened to protect livestock from snow leopard.

Himalayan brown bear killed livestock inside corrals at night, although some were also killed in the open. Bear never attacked livestock that are grazing in group and attended by herders (Pers. Comm. Abdullah, Village Headman). Therefore, most of the domestic animals that were attacked by bears were stragglers on their way to home.

Wolf and snow leopard killed maximum number of livestock in autumn and winter, and less in other seasons. Bears attacked livestock mostly in the autumn, before going into hibernation, and in the spring, after they emerge from hibernation. Although we cannot say with certitude, there is probably an increase in the bear population or scarcity of food in the region. Unlike in the past, the bears have been observed roaming around in the months of December and January, the peak winters and emerging from hibernation in February (Pers. Observation). Thus, their hibernation schedule has changed due perhaps to warming climate and greater availability of food at military camps. Pertinently in the Himalayas Dar et al., (2021) predict climate change as a threat to their habitat. These aspects further need to be investigated largely in face the intensifying human – bear conflict.

6.5.3 People's perception and attitude

Local people had the most negative feelings towards bear (n= 27) despite the fact that wolf caused more damage to livestock. Most of the respondents advocated for their persecution or trapping and few insinuated capturing all the bears and sending then to zoos. Such attitude towards carnivore in general and bear in particular was due to the

conflict between humans and these carnivores, as reported elsewhere (Aryal et al., 2014; C. Li et al., 2015).

Bear apart from livestock killing did considerable damage to property and attacked humans too. Also bears are known as greedy animals and if they are disturbed and are made to leave a place, it returns and the extent of damage increases multi – folds.

Also, as the comparative frequency of brown bear interaction with humans is higher than other carnivores its vulnerability to retaliatory killing is also expected to be very high. However, there was no report of persecution of brown bear and snow leopard from the study area (Image 6.1). This could be attributed to the relatively less killing by snow leopard and depredation by the brown bear only in the recent years in comparison to by wolf. The practice of hunting wolf pubs by angry farmers were reported from the study area. We did not observe any pit traps as reported from Gya – Miru area of Ladakh (Namgail et al., 2007) and Spiti, Himachal Pradesh (HP) (Mishra, 1997). Altogether we suspect the practice of retaliatory killing still exists as livestock killing is frequently reported and monitoring and mitigation measures are not spread evenly to curb it.

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Image 6.2: Human wildlife conflict in the study area

Chapter 7: Conclusion and recommendations

7.1. Conclusion

Overall dependency on rangeland has declined in the valley. People in the past collected fuel wood from the mountains, such as junipers and betulla species, fodder plants mainly Prangos (*Prangos pabularia*), and food plants. Qualitative assessment of rangeland use revealed the abandonment of fuel wood collection. The collection of fodder plants and food plant has also reduced. This pattern of resource utilisation declined sharply due to opening of the road from Zoji – La in 1974, which connected the valley to external market and access to food made easy. But it was the 1999 war which exceptionally changed the past practice of resource utilisation, as it increased employment opportunity, increasing income of the people and also restricting livestock movement. Except for pressure of livestock grazing on rangeland there is no immediate resource use pressure on the rangelands in the valley. However livestock presence are said alter habitat use by wild herbivore thus competitively excluding them form the area (Namgail *et al.*, 2010).But such critical findings and its generalization across the rangeland are criticised as species composition are found increasing for the camping site where livestock are penned during night (Saberwal, 1996). Such findings and lack of local support hindered conservation efforts as conflict arise due to restricting locals for using rangelands (Tambe and Rawat, 2009). Though, in view of decrease livestock population and decreasing resource use pattern we conclude that wild herbivores will be benefited

7.2. Recommendations

i. Rangelands provide a large number of ecosystem services including forage for livestock, high value medicinal plants, cultural and regulatory services, habitat for several globally threatened species of flora and fauna, watersheds function for the local as well as downstream communities and carbon sequestration. The pastoral and agro-pastoral communities have played significant role in maintaining the structure and function of the rangelands. However, these services have not been valued and integrated into development plans. Hence, it is recommended to commission a study on participatory valuation of ecosystem services from the rangelands of Ladakh. This will greatly help in formulating the appropriate mechanisms of payment for ecosystem services and rangeland policy for Ladakh.

ii. Documentation of good herding practices and traditional knowledge on the pastoral production system needs to be initiated. This should include SWOT analysis of traditional service exchange systems viz., Lhangde, Bess, Bonglud, Raress and Baress.

iii. There is a need to establish community fodder banks cum grazing free reserves (15 – 20 ha) for propagation of high value native forage species. Such banks would also serve as reservoir for propagules (seeds and rhizomes) of high value medicinal and aromatic plants, fodder species as demonstration plots.

iv. Prepare landscape level plans for livestock grazing for each block taking into account the summer and winter pastures, important watersheds, critical wildlife habitats. The recently initiated GoI scheme "Project Snow leopard" will be of immense help in the management of alpine rangelands at the landscape level. Prepare a list of do's and don'ts pertaining to use of space such as critical watersheds, courses of streams, important wildlife habitats by tour operators, defense personnel and other

development agencies. Traditional herding practices should be taken into consideration while preparing such plans.

v. There is a need to initiate a comprehensive Rangeland Monitoring Programme for Ladakh. 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 'Long Term Ecological Observation network of Ministry of Environment, Forest and Climate Change (MoEFCC), ongoing programmes of national and state level institutions / University Departments.

vi. We conclude that Tibetan wolf are the most important predators. Loss attributed to snow leopard is huge as livestock lost per incident is high relative to other two carnivores. Bear are notorious as in addition to livestock depredation they damage property. Furthermore, livestock depredation by wolf and snow leopard occurs in autumn and winter whereas brown bear kill livestock in spring and autumn. Retaliatory persecution of wolves is reported. However there is no reported persecution of snow leopard and bear. Though, people despise bear the most than other carnivores.

vii. In order to win the support of locals communities for wildlife conservation and to minimize negative attitude towards carnivores we propose a three pronged approach in the area, viz., conservation education and awareness camps in the area so as to show concern about the problem; initiate livestock insurance and fast track compensation in event of livestock depredation; support local communities in the improvement of

corrals and better animal husbandry practices so as to reduce the chance of livestock depredation.

viii. Currently there is an acute shortage of frontline staff in all line departments, more so in the Department of Wildlife Protection. The staff does not have any incentive to work in harsh conditions and remote locations. Nevertheless, they are they are expected to perform multiple tasks such as protection of wildlife, supervision of home-stay eco-tourism in various areas, implementing compensation schemes for livestock and crop losses to wildlife, and organize nature education activities. Most park staff lacks the necessary clothing, equipment, housing, and training necessary for effective work in the region. Thus, a special drive to recruit frontline staff in key departments and their training would go a long way in achieving the goals of sustainable rangeland management.

ix. Develop a Rangeland Management Training Programme for the frontline staff of Forest / Wildlife Department. Conventional Course on Forest Management at Indira Gandhi National Forest Academy (IGNFA) or Central Academy of State Forest Service (CASFOS) Dehradun do not cover Rangeland Management. The Govt. Of UT of Ladakh may write an appropriate letter to the MOEFCC regarding special curricula for the forest officers who would be posted in Ladakh in future.

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Annexures: Seminar, conferences and publications

Seminar and Conferences

NATIONAL SEMINAR ON HIMALAYAN BIODIVERSITY CHARACTERIZATION AND BIOPROSPECTION FOR SUSTAINABLE UTILIZATION

Livestock depredation by large carnivores in Kargil, (Ladakh), Indian Trans-Himalayas

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Abstract

In the Trans-Himalayan region of Ladakh, the mainstay of the economy of local communities is agro-pastoralism. Since local people share habitat with several carnivores some level of conflict is inevitable. We examined livestock predation, attack on humans and economic loss by large carnivores in Wakha valley. Villagers reported losses of 107 animals to carnivores in a period of three years ending in 2016 with an annual loss rate of (0.5%). Our results suggest that wolves are the most important predator (33%) followed by brown bear (32%), snow

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CERTIFICATE OF PRESENTATION

This is to certify that Mohd Raza participated and presented a paper entitled Agro – pastoralism in Ladakh: current trends and challenges in the oral session of the 3rd International Web-Conference on "Natural Resource Management for Global Food Security and Sustainable Development Goals" Organized by the Academy of Natural Resource Conservation and Management (ANRCM), Lucknow in association with Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Iruvakki, Shivamogga during 2-3 December, 2022 on the occasion of "World Soil Day-2022"

Ajay K Bhardwaj, Org. Secretary | M S Nagaraja, Org. Secretary | Satyaj Arora, Secretary ANRCM | Atul K Singh, President ANRCM

Papers

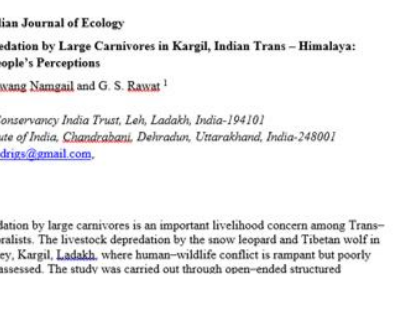
Springer

World Sustainability Book Series
Book Title: *Threatened Medicinal Plants in the Indian Himalayan Region - Sustainability Challenges and Conservation Strategies*
Series Editor: Christian Witschel
[2-06-2024]

Subject: Acceptance of Chapter Submission

Dear Aimon Bushra, Amit Kumar, Gautam Talukdar, Hitendra Padalia, Jikmat Stanzin, Mohd. Raza, and Gopal Singh Rawat

I am pleased to inform you that your chapter titled **"Plant diversity in hay meadows of Ladakh, Indian Trans-Himalaya, with an emphasis on ethno-medicinal and fodder species"** has been accepted for publication in the upcoming book of the World Sustainability Book Series, titled *"Threatened Medicinal Plants in the Indian Himalayan Region-Sustainability Challenges and Conservation Strategies."*



Accepted in Indian Journal of Ecology

Livestock Depredation by Large Carnivores in Kargil, Indian Trans – Himalaya: Patterns and People's Perceptions

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Abstract
Livestock depredation by large carnivores is an important livelihood concern among Trans–Himalayan pastoralists. The livestock depredation by the snow leopard and Tibetan wolf in the Chiktan Valley, Kargil, Ladakh, where human–wildlife conflict is rampant but poorly understood was assessed. The study was carried out through open–ended structured