

RESEARCH

Open Access



# Pastoral practices, pressures, and human-wildlife relations in high altitude rangelands of eastern Himalaya: A case study of the Dokpa pastoralists of North Sikkim

Nisam Mang Luxom<sup>1</sup>, Rashmi Singh<sup>2\*</sup> , Laktsheden Theengh<sup>1</sup>, Priyadarshinee Shrestha<sup>1</sup> and Rishi Kumar Sharma<sup>1</sup>

## Abstract

The pastoral practices of the Dokpa herders of North Sikkim have been transforming in response to the geo-political and socio-economic changes in the region. Against the backdrop of these changes, this study aims to understand the current state of pastoralism in North Sikkim with three specific objectives: (i) to understand the current rangeland management practices of the Dokpa community; (ii) to examine the social, political and ecological stresses to continuity of traditional pastoral livelihoods; and (iii) to document the baseline on human-wildlife relations. We focused on one of the two subset populations of Dokpa herders of North Sikkim and, using a mixed-methods approach, conducted 12 semi-structured interviews, four key respondent interviews and two focused group discussions. The resource use by the Dokpas is unique, and unlike the rest of the Himalayan range, they access the high-altitude pastures in winters and the lower ones in summer. Pastures in the higher altitudes experience heavier winds, which leads to lower levels of snow deposition — thus ensuring access to dried pasture forage for livestock during the lean season. The decisions pertaining to resource management are taken by the head of the local institution *Dzumsa*, the *Pipon*. Primary stresses to the continuation of traditional pastoral practices are fragmentation of pastureland post-Sino-Indian war of 1962 and the consequent establishment of armed forces, livestock depredation by free-ranging dogs followed by wild predators and continued socio-economic marginalisation of the pastoralists under a supposedly egalitarian institutional regime. Extreme climatic events in the recent past have also contributed to significant livestock loss. Dokpa transhumant practices are on an overall decline, with most members of the younger generation shifting to non-herding livelihoods. The availability of alternate livelihood options with the improved connectivity, access to education and development of the tourism industry has led to changing aspirations of the younger generations. In only two of the twelve households we surveyed, the younger generation continues herding, while the rest have moved to the cities and towns. In terms of human-wildlife relations, the respondents mostly hold a positive attitude towards wildlife and conservation actions despite livestock predation by wild predators, since the free-ranging dogs cause the highest livestock loss. With the inputs from the Dokpas, we provide recommendations towards a facilitative environment for the continuation of the traditional herding in the region, which is critical for the survival of pastoralism in North Sikkim, presently hinged on less than two dozen of elderly Dokpas.

\*Correspondence: rashmi89singh@gmail.com

<sup>1</sup> World Wide Fund for Nature (WWF), New Delhi, India  
Full list of author information is available at the end of the article

**Keywords:** Pastoralism, Socio-political stresses, Institutions, Climatic change, Free-ranging dogs, Participatory rangeland conservation

## Introduction

Rangelands cover over half of the earth's terrestrial area and sustain a great diversity of wild animal populations outside protected areas (Toit et al. 2010; International Livestock Research Institute (ILRI), International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), and International Land Coalition (ILC) 2021). They support around 200 million pastoralists globally (FAO 2001), who are the prime inhabitants of the region. Rangelands are characterised by low-productivity environments with patchy resource distribution across time and space. Pastoralists adopt a mobile lifestyle to best utilise the ecological and climatic variabilities. Pastoralists have been classified depending on their degree of movement and their dependence on livestock-based activities as nomads, transhumant and agro-pastoralists (FAO 2001; Global Drylands Imperative 2003). The movement of nomads displays substantial adaptability according to the varying temporal and physical availability of natural resources. Transhumant pastoralists move along a fixed migratory path every year with predefined points established for a more extended stay during the movements. Pastoral communities use mobility as a key adaptation and risk management strategy to optimise resource use and to help minimise livestock losses (Krätli and Schareika 2010). In addition to mobility, Niamir (1990) has put forth (a) pasture rotation, (b) rangeland monitoring protocols and (c) rangeland improvement practices as the characteristic features standard across numerous pastoral groups of the globe. These features are necessary to ensure the sustainable use of natural resources and are well embedded in the traditional ecological knowledge accumulated over several generations of pastoralists (Niamir 1995; Fernandez-Gimenez 2000; Oba and Kotile 2001).

Pastoralists often inhabit remote areas and primarily depend on natural resources for their survival and livelihood. Due to the patchiness of rangeland resources, there is an inherent risk associated with pastoral livelihoods. According to Agrawal (2008), pastoralists can distribute climate-related risks across space — through mobility, time — through storage, households — through communal pooling, and asset classes — through diversification and market exchange. Global climate change further compounds the climate-related risk embedded within pastoral livelihoods. Pastoral communities are predicted

to be disproportionately impacted by climate change, and high-altitude pastoralists are one of the most vulnerable sections of society in the face of unpredictable climatic events (IPCC 2001; Füssel 2010; Macchi et al. 2011).

In addition to being vulnerable to climatic and ecological elements (IPCC 2001; Füssel 2010; Macchi et al. 2011), pastoralists are often socio-economically marginalised groups and have a history of exclusion by the state and state-induced policies (Nori et al. 2005). States have historically attempted to settle migratory societies — a process referred to as sedentarisation (Sahlins and Scott 2001). States implement such policies to govern better and provide government services and welfare measures to remote pastoral societies more efficiently. However, most conservation policies have been rooted in the perception that pastoral societies are backward and that rangeland degradation is imminent in congruence with the principle of “tragedy of the commons” in cases of common property pastoral resources, as proposed by Hardin (1968).

Currently, pastoral communities across Asia and Africa face a range of socio-economic, environmental and political pressures that influence their access to critical natural resource areas and consequently their efficiency to adapt to the change around them. Additionally, inherent disparities in wealth and power are common within pastoral communities, even those viewed as *egalitarian* (Salzman 1999). This disparity further increases during times of stress (Little 1985; Fratkin and Roth 1990; Mworira and Kinyamario 2008; Jacquesson 2010; Gentle et al. 2014). Rapid socio-economic and developmental changes have influenced pastoral communities across South Asia (Kreutzmann 2012).

In the high-altitude region of South Asia, pastoral practices continue to adapt in response to the changing social and ecological environment (Galvin 2009). However, these changes are also influencing pastoral communities negatively. With the socio-economic and geo-political changes, pastoral communities have been reported to (a) modify migratory routes (Gooch 2004; Jasra et al. 2016), (b) change the composition of livestock holdings (Singh et al. 2015), (c) adopt a sedentary mode of high-intensity livestock rearing (Singh et al. 2013; Xu et al. 2008), (d) diversify their livelihoods to supplement pastoral practices (Lenaiyasa et al. 2020; Tiwari et al. 2020) or (e) eventually abandon pastoral practices (Pantuliano 2010).

In addition to the social, economic and political stresses, conservation policies and plans implemented

after limited or no consultation with pastoralists add another layer of stress to their livelihood. In parts of the Himalayan region, discriminatory governmental policies have limited opportunities for social and economic advancement and further perpetuate their marginalisation (Singh et al. 2021; Singh et al. 2022). Pastoralism in the Himalayan and Trans-Himalayan regions is a common livelihood strategy that has developed as a social response to ecological conditions (Brown 1987; Gooch 1992; Miller and George 1996). Pastoral lands in the region hold geo-political importance due to their proximity to India's international boundaries with China, the autonomous region of China (the Tibet Autonomous Region (TAR)) and Nepal. Pastoralists of the region operate across, or in proximity to, physical and political boundaries, which make them vulnerable to geo-political events.

The vast stretches of rangelands used by migratory pastoralists are also habitats of several species with critical conservation values. Livestock predation is a crucial challenge faced by pastoralists in the Himalayan region (Aryal et al. 2014a, 2014b; Chetri et al. 2019; Habib et al. 2013; Mishra 1997; Namgail et al. 2007b; Oli et al. 1994). Livestock predation by wild carnivores has been reported to impact local attitudes towards wildlife conservation and has led to incidences of retaliatory killing of wildlife, including the Tibetan wolves and snow leopards (Bagchi and Mishra 2006; Karanth and Madhusudhan 2002; Jackson and Wangchuk 2001; Li and Zhi 2014). In shared, multiple use landscapes, community attitudes toward wildlife is, therefore, an important issue that should be addressed at the stage of designing the conservation plans and interventions. Government compensation schemes for livestock losses to wild predators have been introduced to mitigate economic loss due to livestock predation. However, inadequate implementation of these policies due to limited monetary resources and a convoluted and tardy registration process has impeded the smooth operation of such schemes across the Himalaya (Jackson et al. 1996; Namgail et al. 2007b; Tiwari et al. 2020; Mishra 1997).

Given the complex interplay between pastoral livelihoods, rangeland dynamics and human-wildlife relationships, an "in-depth" understanding of the pastoralist's resource use and rangeland management strategies, associated social, political and ecological stressors, reliable information on livestock depredation and attitude towards wildlife is necessary for a holistic understanding of issues and design of interventions.

Maintaining rangeland health and the local livelihoods in the Himalayan region requires a participatory approach that engages with the pastoralist's knowledge and pastoral institutions (Singh et al. 2021). It is vital to

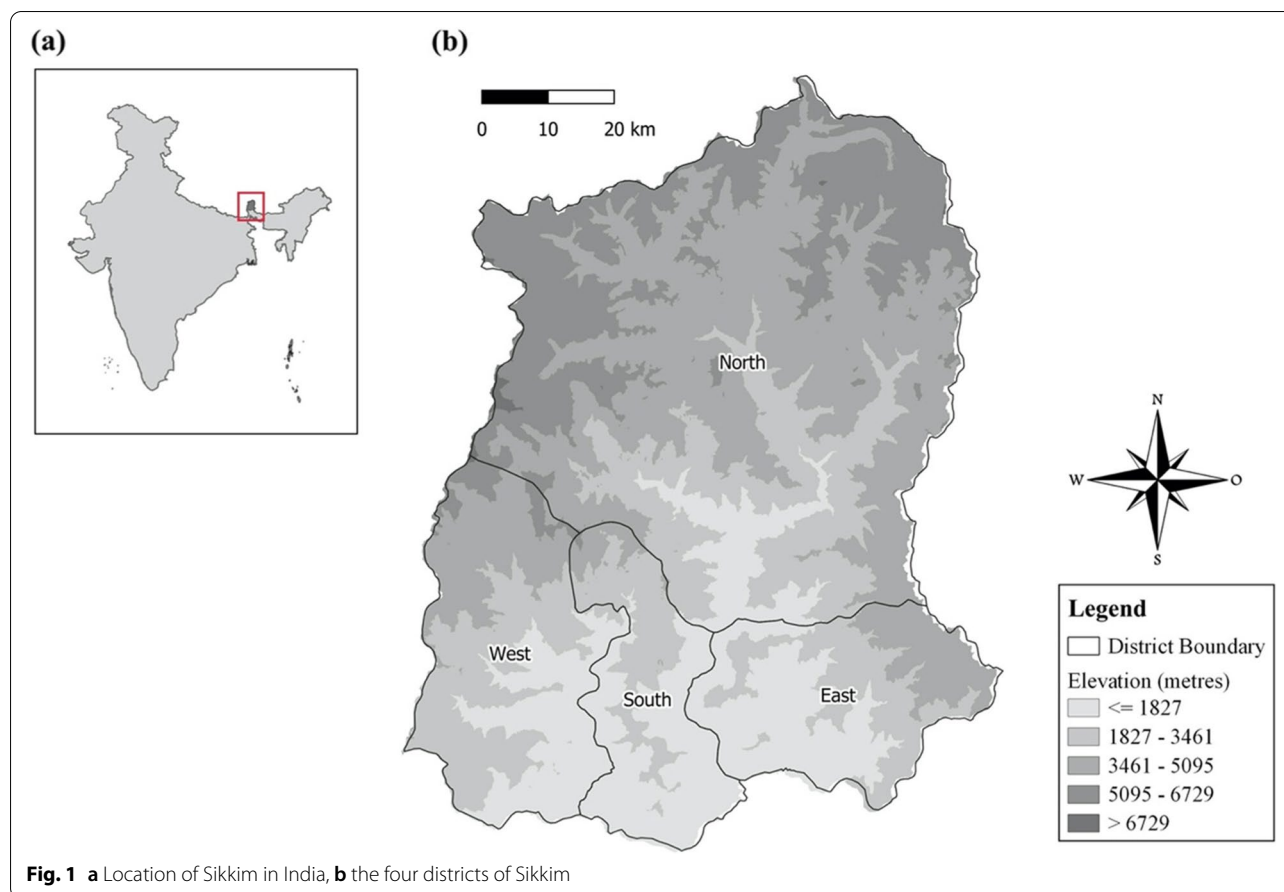
develop an understanding of the pastoral socio-ecological system and nature of interactions among various social and ecological actors for formulating conservation interventions (Berkes 2004; Wrobel and Redford 2010).

Following this approach, this study aims to document the changes and continuities in a lesser-known Dokpa pastoral system of North Sikkim, situated in the Eastern Himalaya, and to document the stresses associated with the continuity of pastoral livelihoods in the region. The Dokpas are a transhumant pastoral community that rear their livestock in the Trans-Himalayan region of North Sikkim. This study is critical because there are only 24 Dokpas left in the region, mostly consisting of elderly pastoralists and a few hired herders.

The region has undergone an immense political and socio-economic change in the past which has influenced the pastoralists and pastoral system to a great extent. Traditionally, the main sources of livelihood in the North district of Sikkim were trading and nomadic pastoralism carried out via trans-boundary movement between the Indian and Tibetan borders (Subba 1989). The Sino-Indian war of 1962 led to the closing of the India-TAR international border and the establishment of defence personnel, mainly the Indian Armed Forces and the Indo-Tibetan Border Personnel (ITBP), in the region. The Chinese occupation of Tibet in 1959 restricted pastoral movements, but after the events of 1962, cross-border movements were completely stopped. In this context, we are interested in studying how the *Dokpas* cope with these changes and exploring the main factors driving changes in their traditional pastoral practices. We also explore the social and ecological challenges they face and identify ways in which external agencies can assist them in sustaining their livelihoods. The specific objectives of our study are (1) to examine current rangeland management practices of the Dokpa community, (ii) to document the stresses and challenges associated with continuity of pastoral livelihoods and (iii) to provide a baseline on herder-wildlife relations in the region.

### Study area

Sikkim is a small mountainous state in India with a geographical extent of 7096 km<sup>2</sup>, covering only 0.2% of the country's total area. The state also has historical political importance due to its geographic location at the international boundary between India with Nepal to the west, Bhutan to the east and Tibetan Autonomous Region, China (TAR) to the north. The state's vast altitudinal (from 300 to 8598 m a.s.l.) and eco-climatic variation has resulted in a biodiversity-rich region. Sikkim forms a part of the Eastern Himalayan biogeographic hotspot and serves as a habitat for several endemic and threatened



**Fig. 1** a Location of Sikkim in India, b the four districts of Sikkim

species of conservation importance (Myers et al. 2000; Mittermeier 2004).

This study was conducted in the North district of Sikkim (Fig. 1). North Sikkim (27° 25' N to 27° 11' N latitude and 88° 53' E to 88° 26' E longitude) is the largest district of Sikkim, with an area of 4226 km<sup>2</sup>. Although its geographical extent covers 59.7% of Sikkim, it is the least populous district in the State, with a population density of only 10 persons/km<sup>2</sup>. The North Sikkim rangelands are characterised by harsh weather conditions, high aridity and a short growing season of 4 months. These rangelands are grazed by domestic herbivores such as domestic yak, sheep and horses, as well as wild herbivores, including kiang (*Equus kiang*), Tibetan gazelle (*Procapra picticaudata*), argali (*Ovis ammon*), blue sheep (*Pseudois nayaur*) and burrowing mammals. These herbivores serve as the prey base for the region's wild carnivores, including the snow leopard (*Panthera uncia*) and the Tibetan wolf (*Canis lupus chanco*).

Most Dokpas originally belong to the neighbouring TAR, China, with a few from Sikkim who only started rearing yaks in the past three decades. There are two sub-groups among the Dokpas: (1) the Muguthang

Dokpa sub-group, whose yaks are taken to the wintering pastures in the Naku Valley, and (2) the Tso Lhamo sub-group who move towards the Tso Lhamo area in the winter. As of December 2020, there are 12 households in the Muguthang sub-group and 12 households in the Tso Lhamo sub-group. This study is focused on the Tso Lhamo group and was conducted in Lachen Valley, where the Tso Lhamo Dokpa sub-group reside and herd their livestock. Livestock reared by the present Dokpas includes the Tibetan breed of yak (*Bos grunniens*) and the Tibetan domestic sheep (*Ovis aries*), locally known as *bherlung*. According to the official government records, the number of yaks in Lachen is 2588, and sheep are 230 (Animal Husbandry Statistics Division 2012).

## Methods

Data was collected between August and December 2020. We employed a mixed-methods approach, which included semi-structured questionnaires, key informant interviews and focused group discussions with Dokpa herders. We covered 50% of the total Dokpa population (12 out of the 24 Dokpa households of North Sikkim),

comprised of residents of the Tso-Lhamo subset. A total of twelve semi-structured interviews with each head of a household of the Tso Lhamo Dokpa sub-group were conducted.

Qualitative questions from the semi-structured interviews aimed to address information regarding (i) the current grazing regime, (ii) drivers of change in pastoral practices, (iii) the role of local institutions and (iv) the pressures faced by Dokpa pastoralists in continuing pastoral practices. Quantitative details regarding the livestock holding size and the number of livestock lost to wild predators and free-ranging dogs were noted separately for every household.

To understand the resource use, we identified Dokpa camp site locations and mapped out the grazing route on Google Earth with the help of four key informants. Additionally, we conducted two group discussions with four herders each for the triangulation and better perspective on the challenges faced by the herders and their potential solutions. We also had two key informants, who did not actively practise high-altitude herding but had given their livestock to be taken care of by the Dokpas. We corroborated information obtained through the semi-structured interviews and informal conversations with Dokpa herders with these two key informants.

## Results

In the following sections, we present information on the Dokpas and their pastoral practices. We then explore how the formative events stated above have impacted Dokpa pastoral practices and introduced new challenges to the community. The role of local institutions in managing pastoral resources and challenges associated with the institutional management regime is also detailed. We then briefly explore the perception of Dokpa herders towards wildlife and conservation initiatives in the region.

### Livestock management, institutions and resource use

The Tso Lhamo Dokpa sub-group's herders consist of 12 households, out of which 11 households rear a total of 1398 yaks, on an average of 127.09 yaks per household ( $n = 12$ ), and one household rears 200 *bherlung* sheep. The Tso Lhamo sub-group stays close to the Phalung area during the summer and in Tso Lhamo or Gurudongmar during the winter. The Tso Lhamo sub-group and the Muguthang sub-group have separate migratory routes. We present the migratory route for the Tso Lhamo Dokpa sub-group (Fig. 3) along with the elevation profile of the track (Fig. 4).

Each Dokpa household stays in stone huts or temporary tents along their migratory route, locally known as *goath*, set up in valleys near pasture areas (Fig. 5). Their

diet usually consists of *tsampa* (roasted barley flour), rice, yak meat, potatoes, cheese and other milk products. Since they live above the treeline, firewood is not a viable fuel option. Dung cakes are used to light fires to cook and keep warm in extreme weather conditions. Outside each goath, a low-walled enclosure is built from stacks of rocks up to 4 feet tall, which are used as livestock pens.

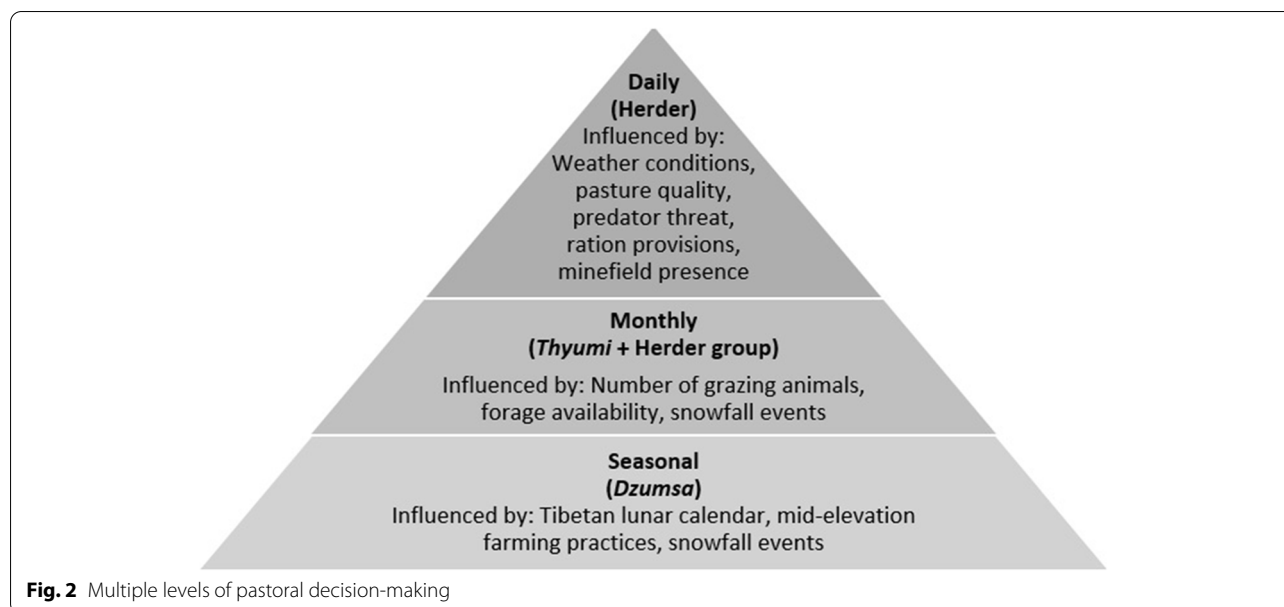
The primary income sources for the Tso Lhamo Dokpas are yak meat and milk product sales to the nearby town of Lachen. Earning opportunities are not available to them throughout the year. The peak season for yak meat sales is at the onset of winter, just before the Dokpas start their upward migration. This period falls before the month of the Buddhist festival Losar, which celebrates the Buddhist New Year. A religious ceremony is conducted before starting the slaughter of the yaks. Up to INR 70,000 or \$948.52 can be earned from the meat sales of one adult yak. After the yak slaughter period, the Dokpas commence their upward movement toward their winter pastures.

In a typical Dokpa household, the men are responsible for taking the livestock herd out to pasture and return only at the end of the day with the animals. The women of the house are tasked with milking the female yaks and making milk-derived products for personal consumption and commercial purposes. Such work requires constant supervision, so the amount of profit generated by a Dokpa household is dependent on the livestock yield, the available manpower and the gender composition of the household.

Pastures of North Sikkim are communally managed; however, this does not imply open access to all users throughout the year. Pasture management is regulated by a local institution known as the *Dzumsa*. The *Dzumsa* system began in the early nineteenth century when Sikkim was an independent country ruled by a monarch, known as *Chogyal*. Such a system enabled the monarch to delegate authority at local levels. After Sikkim's merger with India in 1975, the *Dzumsa* of North Sikkim was formally recognised by the Government of India as the official local governing body<sup>1</sup>. Based on a voting system, the *Dzumsa* selects the *Pipon*, the local title of the village head. One of the responsibilities of the *Dzumsa* council and the *Pipon* is natural resource management, including the enforcement of local laws regarding pastoral resources and the setting price of livestock produce.

The *Dzumsa* has primary control over large-scale seasonal movements of the local pastoralists. After conducting a meeting with Dokpa representatives, the *Pipon*

<sup>1</sup> Sikkim Government Gazette, Extraordinary, Notification no. 7/LD/2001 Dated 12 November 2001



— the elected head of *Dzumsa*, fixes the dates of movement for the different pastoral groups in the region. These include Dokpa yak and sheep herders, who migrate across the high-altitude rangelands (4100–5100 m a.s.l.), and the Lachenpa cattle herders, who move in the lower-elevation areas (below 3900 m a.s.l.). After the monsoons, the Dokpas are instructed to begin their upward migration from summer pastures, and the Lachenpa cattle herders are instructed to start their downward migration towards Lachen. The *Dzumsa* also fixes dates for the further upward movement of *Dokpas* before winter commences. Fines are collected in case of deviations from the designated migratory route and the migration date.

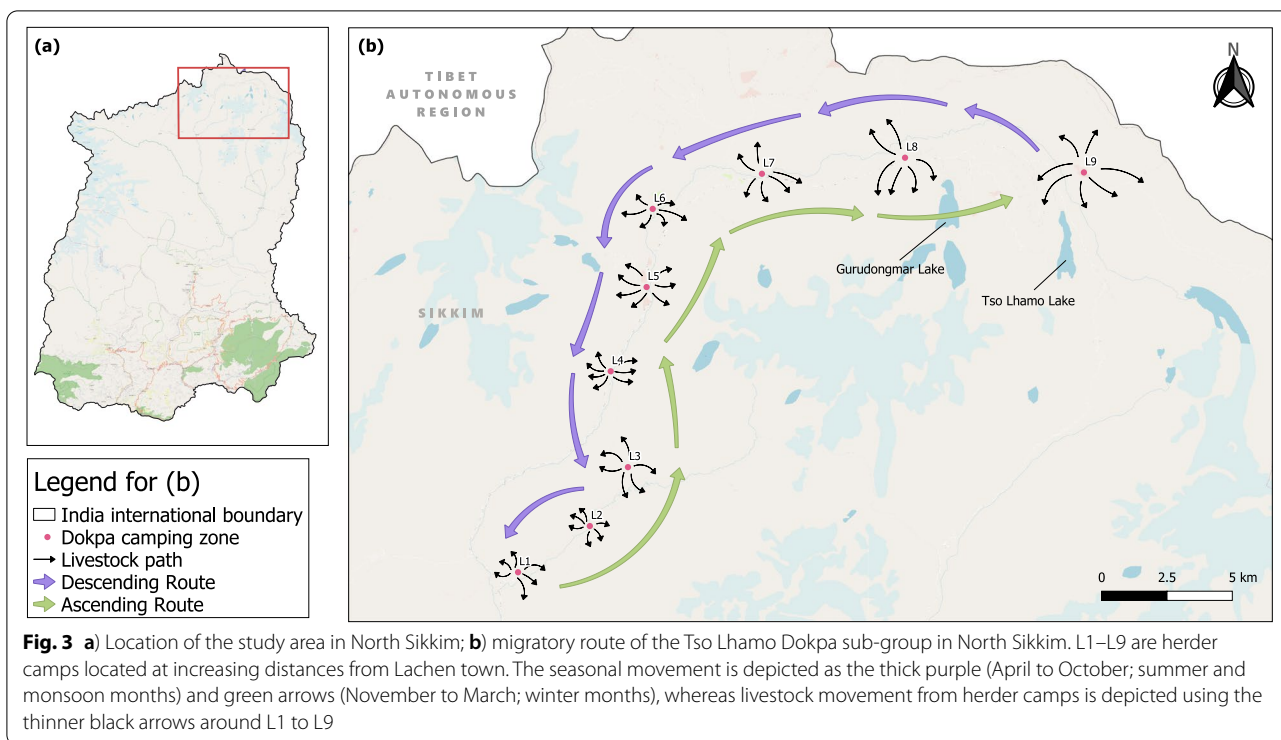
Decision-making regarding Dokpa pastoral practices occurs at three scales (Fig. 2). The *Pipon* does the decision-making at the seasonal scale. Decisions on weekly movements between the designated dates set by the *Pipon* are taken by *Thyumi*, the local name for the Dokpa representative elected by the Dokpas every year. The *Thyumi* is responsible for calling group meetings among the *Dokpa* sub-group and mediating discussions on the group's movement. On a day-to-day basis, the herder is responsible for making decisions regarding the location and duration of livestock pasture use.

While the historical *Dokpa* migratory routes spanned large tracts across Tibet and Sikkim boundaries, the present-day pastoral route is restricted within North Sikkim. The Dokpas migrate along a vertical elevation gradient of over 1000m from 4100 to 5100m. They spend summers and monsoon months (June–September) at comparatively lower elevations ranging between 4100 and 4700 m and move towards higher elevation winter pastures close

to 5100 m during the winter months (Fig. 4). The Dokpas are familiar with the geography of the local landscape and use this knowledge to cope with harsh winters. The herders determine their winter grounds by considering the amount of snowfall received that year as a main factor. At the onset of winter, when snowfall is comparatively lesser, the Dokpas begin to move towards higher-altitude pastures near Tso Lhamo Lake (L9 in Fig. 3b). In case of relatively higher snowfall, the Dokpas utilise the pastures near Gurudongmar Lake. The rationale for this movement towards the Gurudongmar area, as reported by the Dokpas, is to take advantage of the larger and more exposed terrain of those pastures. The Gurudongmar pastures serve as a safer alternative for herders and livestock due to lower levels of snow deposition attributed to its extensive area and windblown nature (Figs. 4 and 5).

#### Factors contributing to declining Dokpa pastoralism

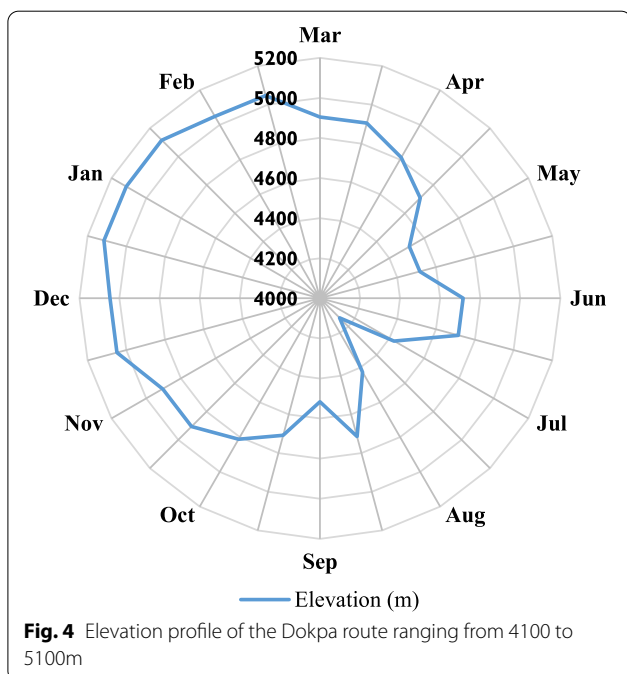
There is a shift of Dokpa pastoralists towards non-pastoral livelihoods (Fig. 6). During our surveys, we observed that out of the twelve households of the herders, the younger generation of only two families continued practising herding. This change has been induced by several factors, including recent changes of increased climatic variabilities, lack of access to governmental support, social marginalisation of the herders in the region, changing aspirations of the younger generation and predation by free-ranging dogs and wild carnivores. The historical causes for curtailed migratory routes and associated social stresses of remote geography also play a critical backdrop for the current state of pastoralism in



North Sikkim. In this section, we explain all these factors in detail.

**Coping with the unpredictability**

All the respondents ( $n = 12$ ) reported erratic weather patterns over the recent years with unpredictable events



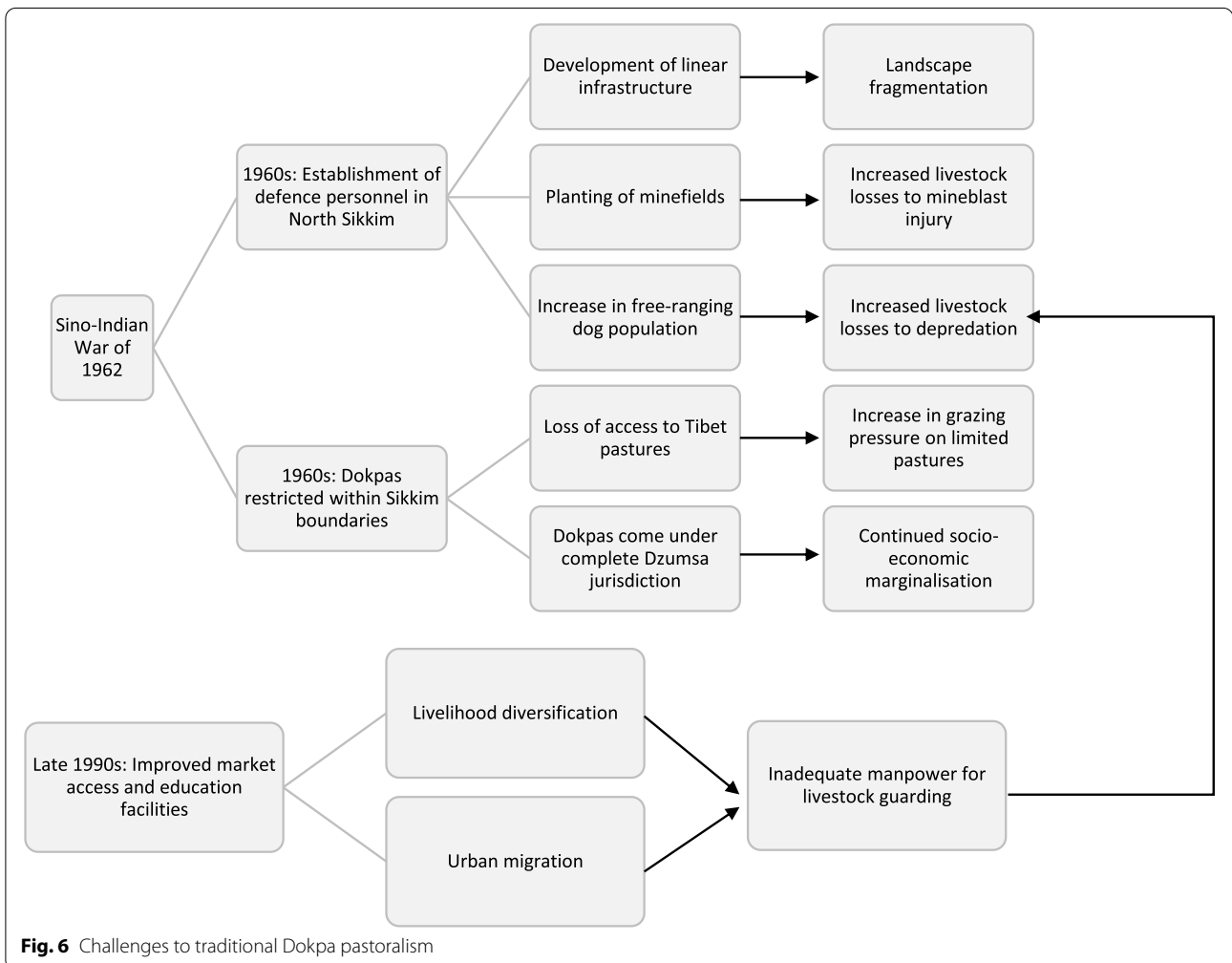
of heavy snowfall and short spells of heavy rainfall, which affected the local vegetation negatively. They also mentioned that with the climatic variabilities, there is insufficient forage availability in the pastures, which has also influenced livestock health. Given the lack of adequate forage availability, the yaks become weak and do not have the strength to escape from predators. The Dokpas also noted the shifting seasonal patterns, especially the delayed onset of winters and snowfall, which has also resulted in shifts in migration timings, with the Dokpas shifting to the high-altitude pastures after a more prolonged stay in their autumn pastures.

All respondents reported that the winter months (December to March) are the most challenging time due to the forage shortage and extreme weather conditions. Snowfall during winter makes the dried-up ground forage inaccessible to livestock, so they supplement the diets of their livestock with animal feed. Although the Dokpas and their livestock face hardships during winter seasons of heavy snowfall, one of the respondents noted that adequate snowfall during the previous year also resulted in high-quality pasturage during the following growing season. This kind of snowfall has become a lesser-known event and it occurred after several years of erratic snowfall. According to him,

*The heavy snowfall we had last year wet the soil nicely, so the ground forage regeneration was excep-*



**Fig. 5** A typical Dokpa camp — stone huts (visible in the background) with livestock pens nearby



**Fig. 6** Challenges to traditional Dokpa pastoralism



*tionally good this year. Good quality pastures fatten our yaks up a lot. But during years of heavy snowfall, our yaks have higher risk of not making it through the winter. It is a cycle of loss and profit.*

#### **Establishment of armed forces and associated challenges**

After the Sino-Indian war of 1962, a network of roads and bridges was constructed to facilitate the movement of defence troops. A government organisation known as the Border Roads Organisation (BRO) has also been established for making and maintaining road networks. The international India-China border closure had cut off access to the winter pastures on the Tibetan Plateau. The stationing of defence personnel into the region resulted in the fragmentation of the landscape with the rapid construction of linear infrastructure. It further restricted movement and access to pastureland in an area with already limited grazing resources. Minefields that were unplanned and placed at the time of the war continue to detonate and cause injuries and deaths to the livestock and wildlife in the region.

The food waste generated at army camps supports a burgeoning population of free-ranging dogs that attack wildlife and livestock. The population of free-ranging dogs has increased with the strengthening of the army presence in the area. All the Dokpas concurred that the depredation by free-ranging dogs was as urgent a problem as depredation by wild predators if not more. Free-ranging dogs target young livestock throughout the year and adult livestock during the lean winter periods when limited forage depletes their strength. Each Dokpa household lost an average of 9 ( $\pm 5.54$ ) livestock per year to predation by free-ranging dogs.

The issue of livestock predation by free-ranging dogs is further compounded by the presence of minefields in the area. Herders do not allow their livestock to graze inside minefields. Due to these restrictions, the forage in these minefield areas is lush green when all other areas are grazed. Forage insufficiency in the usual pasture areas during lean seasons drives yaks to run away toward minefield sites in search of forage. Such areas are poorly fenced, so wild and domestic ungulates easily enter these sites, trigger mine blasts and injure themselves. One yak herder spoke about the minefield problem saying,

*Minefields injure our animals and make them weak. If they're not killed immediately, they're eaten by dogs. The feral dogs in the region are getting stronger and hunt more and more animals.*

#### **Social challenges associated with the remote geographies**

The closure of the Indo-Tibet borders has closed not only the international borders for animals and goods

but also marital relations, which were prevalent across borders before the 1960s. The decline in the number of active Dokpa herders is also attributed to the shortage of marriage prospects in the region. Dokpa women have increasingly taken up marriage prospects from other communities, while Dokpa men have remained bachelors or married in the village of Lachen. The Dokpas pointed out the lack of healthcare facilities as a major limitation. They note that several women have suffered during childbirth due to inadequate health facilities. Dokpas now rely on medical facilities at army camps for primary healthcare. Heavy winter snow also acts as a significant impediment to regular movement and cuts off the Dokpas from healthcare facilities, which are already remote in the first place. One elderly herder also expressed his grievance about the lack of Buddhist monks or monasteries in the area in case funeral ceremonies needed to be conducted.

Elderly Dokpas concede that they are the last of their generation willing to lead the traditional pastoralist lifestyles of their forefathers. Whereas entire families previously lived in the goath and participated in pastoral activities, the current Dokpa household usually houses the oldest generation capable of conducting livestock herding activities. The younger generation and close relatives are only temporarily present during the busy weeks of yak slaughter season or when extra help is needed in making livestock-based market products. There has been an increasing trend of employing non-local herders, with whom profits are split in cash or kind. Key respondents voiced their concerns regarding the lack of skills and local knowledge possessed by the new group of non-local herders, which could lead to the mismanagement of livestock. They also pointed out the potential for over-exploitation of natural resources by newer herders who unlike the traditional Dokpa pastoralists lack land stewardship and are less concerned about sustainable resource use and nature conservation.

#### **Stresses associated with local institutional bodies**

The Dokpas depend on Lachenpas, people of the nearest village Lachen, not only for market access but also for the local institution *Dzumsa*, which plays a crucial role in livestock management, ensuring sustainable management of the natural resources. The tax collected by the *Dzumsa* annually is distributed among the resident households under the *Dzumsa* collective. This distribution is done by dividing the resources equally or using a random lottery system. Financial and material aid from external agencies is also distributed among the local population via the *Dzumsa* institution. Although the Dokpas have been transiently present in the *Dzumsa* cultural landscape for centuries, it is only after the international border closure in 1962 that they have been permanently

residing on the Sikkim side of the international boundary. As a result, Dokpas are excluded from the *Dzumsa* collective, which is reserved for Lachenpas, and therefore are governed by an institution in which they cannot participate. The *Dzumsa* also mediates the process of obtaining external aid from non-governmental agencies. Such a complex relation between the Lachenpas, the *Dzumsa* institution and Dokpas has led to a state of affairs where Dokpa advancement and interests may be hindered and result in their persistent socio-economic marginalisation.

#### **Changing aspirations and decline in pastoral livelihoods**

The advent of tourism and the promotion of education among rural communities have transformed the socio-economic profile of the landscape. The adoption of livelihood diversification strategies by the Dokpa community to help alleviate their social status and living conditions has been facilitated by improved road connectivity and education reforms. Some of the Dokpas have also invested in their children's education in hopes that the younger generation will be able to engage in better and more lucrative employment opportunities. The younger and educated Dokpa generations have now moved to towns and cities. The daughter of one of the yak herders temporarily helping out her parents during the busy yak slaughter season noted, "If it had not been for schooling, nothing would have changed here". She was a part of one of the first generations of Dokpas who went to school during the late 1990s. Education and improved road connectivity have opened new livelihood options, thus influencing the new generation's choice of work, where most want to move away from the herding practices. Alternate livelihood options for the younger and educated Dokpas include tourism-based opportunities and jobs in private firms or the armed forces. Out of all the Dokpa households in the Tso Lhamo sub-group, only two Dokpa households reported that their children were actively herding. Even among the two, one was unsure about continuing the herding work and was instead hoping to earn a livelihood through non-pastoral work. However, the current Dokpa herders were still reluctant about permanently moving away, even though they sensed the pull of city comforts and easier access to healthcare. They cited their lack of education and consequent lack of earning opportunities to continue their pastoral lifestyle. On asking whether they would move away and settle in a town, one yak herder answered,

*This life of hardships is all we've known and grown up with. If we go to a town and settle there, how will we earn our keep? What will we eat? Who will look after my yaks? We are not educated, so this is the only stable job we can get.*

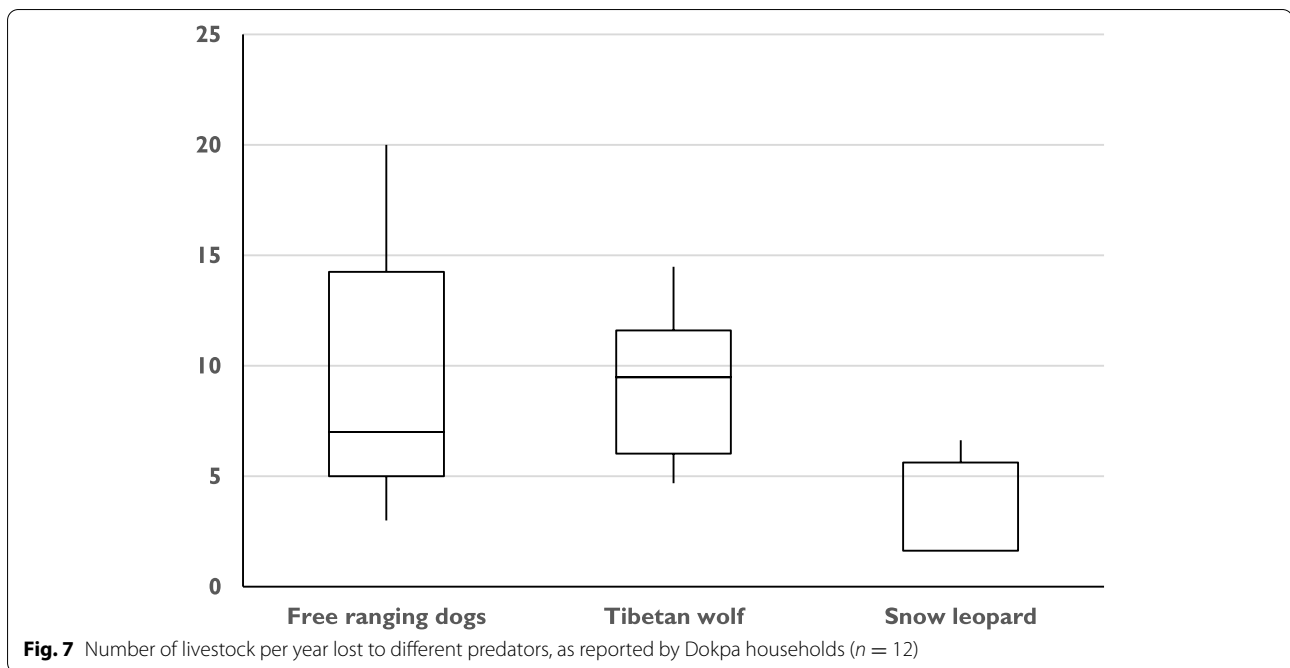
The profitability of Dokpa livelihoods is influenced by the livestock holding type, size and forage availability each year. Large livestock holdings require adequate workforce to carry out responsibilities associated with herding. Urban migration and livelihood diversification have led to a decline in the number of actively herding household members in Dokpa families over time. The reduction in available workforce, combined with the local management's internal issues, has influenced the feasibility of continuing transhumant pastoral practices.

#### **Dokpa livelihoods and wildlife conservation**

The Dokpas are well aware of the wildlife in the area and their preferred habitats. They use this knowledge to avoid areas with high probability of carnivore presence, which could lead to livestock depredation. However, such events cannot be avoided entirely, and livestock depredation by Tibetan wolf (*Canis lupus chanco*) and snow leopard (*Panthera uncia*) remains a significant challenge. According to the Dokpas, livestock predation events by Tibetan wolves are common during the winter season and predation by snow leopards is common at their summer pastures. But the biggest threat to the livestock is depredation by free-ranging dogs as it occurs throughout the year due to the wide presence of army camps in the region.

The lack of workforce compels the herder to leave groups of livestock unsupervised while they freely graze in vast pastures, leaving them vulnerable to predator attacks. Livestock pens also have low walls, which cannot prevent predators from entering and attacking livestock at night. Based on our interviews with the heads of the Tso Lhamo Dokpa sub-group households ( $n = 12$ ), we calculated the number of livestock lost per year to different predators over the last 5 years from 2015 to 2020 (Fig. 7). The self-reported number of livestock lost per year by each household was maximum in the case of dogs at  $9 (\pm 5.54)$ , followed by Tibetan wolves at  $4.68 (\pm 3.41)$  and snow leopards at  $1.63 (\pm 2.08)$ .

Government agencies are responsible for compensating for livestock losses to wild predators. However, the failure of the compensation mechanism put in place by the region's Animal Husbandry and Forest Departments was a widespread grievance among Dokpa households. Yak herders mentioned that the administrative process of compensation provision was very time-consuming and expensive, considering that they had also to bear the cost of travel and leave their livestock unguarded or under the care of another herder. The inadequate amount barely covered the actual economic losses for the few cases where compensation was provided. The budget allotted by the Animal Husbandry department is often limited and unable to provide compensation for all depredation



events. The Dokpas emphasised the need for strengthening anti-predation measures, such as effective guarding and construction of predator-proof corrals, to help minimise livestock losses.

Wildlife conservation activities and research in North Sikkim have mainly focused on local wildlife, especially the charismatic snow leopard and the wild ungulates. Non-governmental organisations have taken up work rallying for snow leopard conservation, promotion of eco-tourism and plastic waste management. We asked respondents their opinions on the benefits and need for such activities to gauge their perceptions towards the larger goal of wildlife conservation. A total of 40% ( $n = 5$ ) of the Dokpas interviewed positively perceived wildlife conservation and acknowledged that further efforts were required to protect local wildlife, including wild carnivores. The remaining 60% ( $n = 7$ ) of Dokpas were neutral about wildlife conservation and contended that they had not been able to claim the benefits that activities associated with wildlife conservation claimed to provide. All the respondents (100%,  $n = 12$ ) had a positive attitude towards wild herbivores. They viewed them as entities with the same interest as their livestock, i.e. pasture quality, safety from free-ranging dogs and free movement across the landscape. They claimed that the forage in the region was enough to sustain both wild and domestic ungulates and noted spatial segregation between wild and domestic ungulates along their migratory route.

Regarding wild predators, only a single respondent believed that active conservation efforts are needed for

charismatic species such as the snow leopard and cited it as a tourist attraction. Due to their strong religious and spiritual beliefs, the Dokpas do not engage in retaliatory killing of wild carnivores. Still, they expressed the difficulty of bearing livestock losses attributed to wild carnivores and a significant depredation pressure from free-ranging dogs. The benefits of taking steps towards conserving wildlife were unclear to them as they associated higher wild carnivore populations with an increase in potential livestock depredation. The issue of livestock depredation was the biggest hindrance to the herders developing a positive perception of wildlife conservation.

## Discussion

The influence of globalisation in the form of market expansion and intensification of road and communication networks has reached even remote Himalayan regions. Such events have helped usher in changes in pastoral and lifestyle practices for transhumant or migratory pastoral groups across the Himalayas, with Farooquee (1998) even attributing the “breakdown” of pastoralist-environment relationships to these events. The socioeconomic changes and better connectivity to the outer world and access to education have influenced the traditional knowledge systems — partly due to changing aspiration of the younger generation and the time they spent away from home during the years of their formal education, emergence of alternate livelihood options and the eventual decline in traditional pastoralism (Farooquee 1998; Clemens and Nüsser 2000; Namgail et al. 2007;

Aryal et al. 2014a, 2014b; Wu et al. 2014; Singh et al. 2015; Gentle and Thwaites 2016). The improved access to education has prompted the younger generation of pastoral communities to explore other opportunities that provide financial security with relatively lesser hardship. Education level has been shown to impact the capacity for adaptation during times of risk negatively (partly due to reduced exposure and experiences in their system) — an agent that pastoralists across the Himalayas are familiar with due to the volatile geo-political scenario and integration of the local markets to the mainstream economy (Wu et al. 2014).

Other than globalisation, and market integration, geo-political instability is another common factor affecting the pastoral practices of indigenous groups across the Himalayan region. The closure of the India-TAR international boundary and the consequent establishment of defence forces after the Sino-Indian war of 1962 affected the grazing practices of pastoralists from Changthang in the north-west to Arunachal Pradesh in the north-east (Chaudhuri 2000; Bhasin 2011). The drivers of change and the adaptation strategies adopted by pastoralists are extremely specific to local site-based factors. There have been changes in pastoral systems in response to the changing times and to help pastoralists keep up with the era of “modern development” and an integrated economy. The consequences of said changes have been observed to lead to intensification of pastoral practices (Namgail et al. 2007) or in the gradual decline of entire pastoral societies and their shift towards non-pastoral sectors (Namgay et al. 2013; Gentle and Thwaites 2016). In both cases, there is a fundamental change in how age-old pastoral practices have been sustained until the present.

Given the remoteness of the landscape and limited connectivity, pastoralists in these regions have a history of marginalisation, with their role as stakeholders in land resources being undermined during policy formulation and implementation (Sharma et al. 2003; Singh et al. 2021). The lack of government support for transhumant herding livelihoods and marginalisation of herders has contributed to the decline of high-mountain pastoralism in the Himalayas. In North Sikkim, we found that the historical events of the war had a leading role in restricting the movement of pastoralists, but social stresses associated with changing aspirations of the younger generation and limited prospects of marriage within a small number of households have contributed to the present situation where the present old Dokpas could be the last generation in pastoralism. Livestock depredation and exponentially increasing free-ranging dog numbers continue to be a significant threat to the continuity of pastoralism in the region.

### Historical events of war and their influence on local resource use

The Dokpas migrate vertically along a route annually, grazing their livestock at lower elevations, i.e. 4100 m a.s.l., during the summer months and moving towards higher elevations, i.e. 4700m a.s.l., during the winter months. The Tso Lhamo Dokpa migration pattern differs from the usual route of high-altitude summer grazing and lower-altitude winter grazing that other yak herding groups adopt, as seen in other parts of the high-altitude regions of South Asia. For example, in Pakistan (Jasra et al. 2016), Nepal (Dong and Zhaoli 2016; Ning et al. 2016), Bhutan (Chophyel 2009), in the western and eastern Indian Himalaya (Singh et al. 2020; Singh et al. 2021) and even in other parts of Sikkim (Sharma et al. 2016), the movement is generally the other way around — higher pastures are used in summer and the lower ones in winters. Historically, the Dokpas moved across a larger area ranging from the Khamba Zong region in TAR for the winter pastures and the rangelands of North Sikkim for the summer grazing. After the closure of international borders, they had to constrict pasture use within the Sikkim pastures throughout the year, which was locally perceived to be a major challenge associated with the limited forage availability. The Dokpas have adapted to the loss of access to pasture areas by reserving the higher-altitude pastures for winter, resulting in a distinct winter-high and summer-low movement pattern that sets them apart from many other pastoral groups. The rationale of this unique pasture use is embedded in the local climatic conditions. Pastures in the higher altitudes experience swift winds during winters, which leads to lower levels of snow deposition — thus ensuring access to dried pasture forage for livestock during the lean season.

Events like trans-boundary closure that transformed Dokpa pastoral practices have also impacted the movements of local pastoral groups in other parts of the Himalayas and Trans-Himalayas. In Ladakh, the closure of the India-Tibet boundary and the rise in *pashmina* demand have led to the eventual increase in the cashmere goat numbers — raising concerns of rangeland degradation due to the intensification of livestock grazing pressure in the limited area (Namgail et al. 2007; Singh et al. 2013). Restriction of pastoral movement and intensification of grazing within a confined area have been noted to lead to over-grazing and pasture degradation in other Himalayan rangelands like in Eastern Nepal (Ning et al. 2016) and Gilgit-Baltistan (Jasra et al. 2016). In the case of North Sikkim, however, the number of herders and their animals have not increased substantially (as observed by the Dokpas themselves) given that pastoralism is on the decline in the region with all the young members shifting to urban

areas in search of jobs and education. Co-occurrence of wild herbivores and livestock, especially in high densities, has also been associated with negative impacts on resource availability for wild herbivores and potentially facilitates competition (Bagchi et al. 2004; Mishra et al. 2004; Shrestha and Wegge 2008; Chanchani et al. 2010). During our interviews, the Dokpas mentioned that livestock and wild herbivores maintain spatial segregation at the micro-habitat level, even for species with overlapping diets. Previous studies where such segregation has been noted have posited it to be a sign of forage competition between domestic and wild ungulates (Shrestha et al. 2005; Namgail et al. 2007a); however, Dokpas noted that there continues to be a co-existence between the wild herbivores and livestock grazing in the study site.

#### **Erratic weather hampering pastoral livelihoods**

The Dokpas reported erratic and unpredictable weather conditions in the past two decades in the North Sikkim rangelands. While weather-related studies specific to North Sikkim are few, Rahman et al. (2012) have reported a 2–3-year cycle of alternating high and low rainfall, compared to the average, for other parts of the state. One of the key respondents had also noted the cyclical nature of the precipitation for North Sikkim's rangelands; however, they could not determine the exact length of the weather cycle in years. Rahman et al. (2012) observed drought and excess rainfall events to be concentrated during the winter months from October to March. Thus, weather patterns in Sikkim tend to be more erratic during the lean winter months, when pastoralists and their livestock are the most vulnerable. Bhattacharya et al. (2012) have also highlighted the predicted increase in the intensity and frequency of extreme events such as heatwaves, droughts and extreme precipitation in Sikkim. An example of the impact of such an event in Sikkim's recent history is the loss of at least 300 yaks trapped due to heavy snowfall in the Muguthang and Yumthang Valleys of North Sikkim (AFP 2019). Increased weather variability has impacted the ability of pastoralists to predict and take precautionary measures against extreme climatic events, leading to massive livestock losses contributing to a major threat to the herding livelihoods in the region.

#### **The Dzumsa, as a governance institution**

In the extensive Trans-Himalayan landscape of North Sikkim, where appropriate resource management and law enforcement by government agencies is hindered by a lack of human resources (Oli et al. 2013), the *Dzumsa*

serves as an essential body for effective resource management. The *Dzumsa* institution and the Dokpas collectively possess a wealth of traditional ecological knowledge, which helps them conduct adaptive management of pastoral resources at a local scale. The repository of traditional knowledge of Dokpas has evolved and been fine-tuned to cope with the local ecological and climatic challenges (Acharya and Ghanashyam 2012; Ingty 2017). The need for implementing such a knowledge system in conservation planning through a participatory framework has been highlighted by several studies (Berkes 2004; Fernandez-Gimenez 2000; Jackson 2012; Miller 1998).

While the *Dzumsa* institution was not specifically devised for nature conservation, its functioning contributes toward the safekeeping of cultural and ecological resources of the Tso Lhamo landscape. The Dokpas, a present part of the cultural landscape governed by the *Dzumsa*, have been reported to be “socio-economically downtrodden” in the social hierarchy of the Lachen population (Acharya and Ghanashyam 2012). During our interviews, Dokpa herders commented on the disadvantages of being subjected to the strict monopoly that the *Dzumsa* possesses over the Dokpa economy and resource access. The Dokpas are thus an anomaly embedded within a system that strives for equal opportunity for all and has otherwise been lauded as an excellent example of “societal management and community harmony” (Acharya and Ghanashyam 2012). While the success of the *Dzumsa* as the upholders of an egalitarian regime for the Lachenpas is beyond the scope of this study, it stands in stark contrast to the drawbacks of the same system in perpetuating Dokpa marginalisation. However, the Dokpas have also noted the increase in inter-group marriages between Dokpas and Lachenpas. In such cases, restrictions on Dokpa households have eased and such relations have mutually benefitted both the ethnic groups.

#### **Livestock losses to depredation**

With the livestock and wildlife sharing overlapping areas, the issue of livestock depredation by wild carnivores is prominent across the Himalayas and Trans-Himalaya (Mishra 1997; Bagchi and Mishra 2006; Chetri et al. 2019; Jamtsho and Katel 2019). The presence of snow leopard and Tibetan wolf around Dokpas has a long history. Still, the issue of livestock depredation by free-ranging dogs is a recent problem in the region. According to the Dokpas, free-ranging dogs have emerged as the main predator of livestock, followed by the Tibetan wolf and snow leopard. Livestock depredation by dogs has also emerged as a major threat to pastoral livelihoods in other parts of the Himalaya (Suryawanshi et al. 2013; Singh et al. 2015).



**Fig. 8** Livestock pens located near a Dokpa campsite

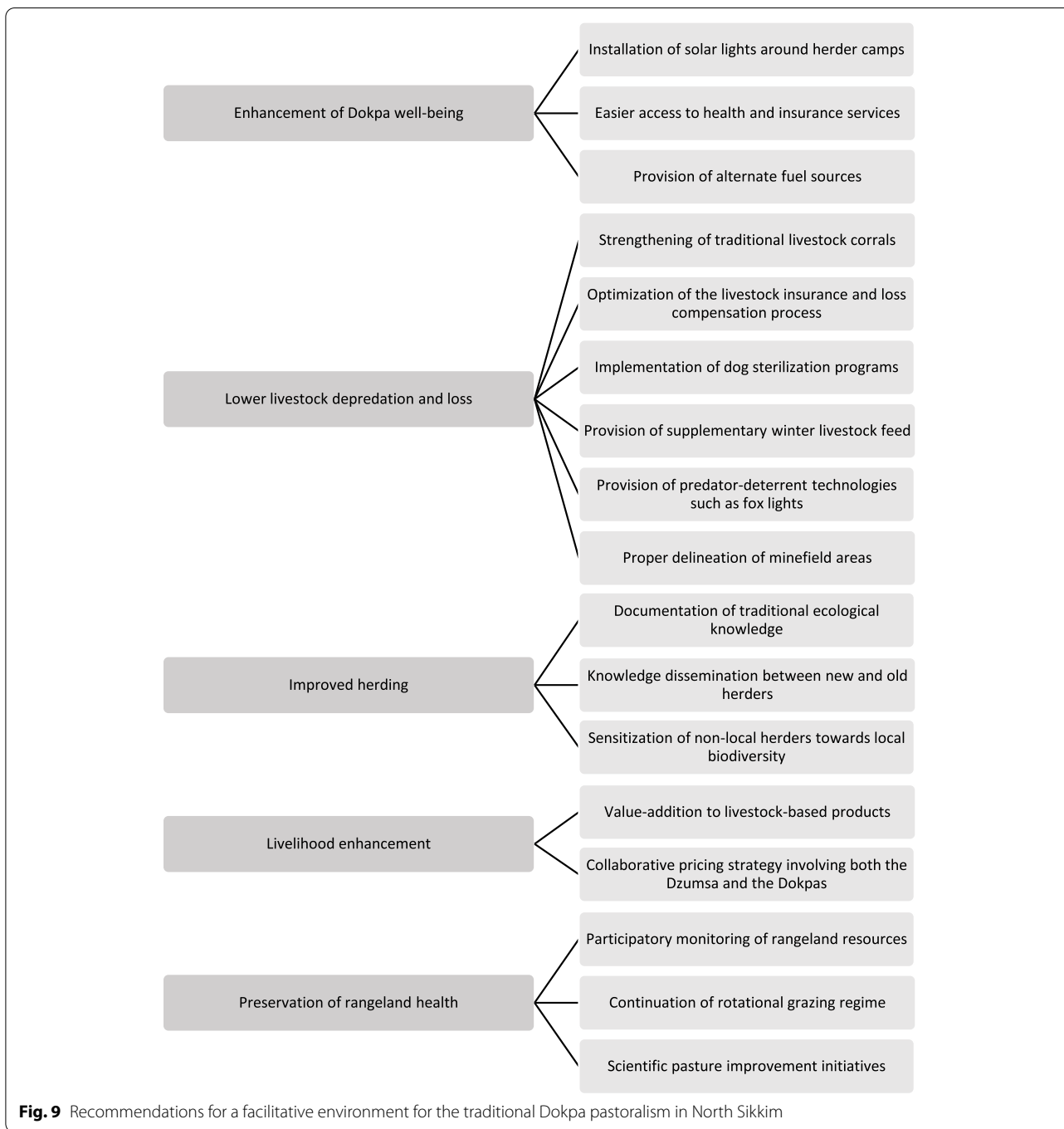
Lax guarding is one of the main factors closely associated with livestock depredation events ( Jackson et al. 1996). Until a few years ago, the whole family participated in livestock herding, where men took care of livestock. Women, elders and kids used to do other chores like milking, collecting fuelwood and creating livestock-derived products. However, the gradual reduction in household size and herding capacity for each household has severely impacted the daytime livestock guarding ability. Another major issue contributing to livestock depredation in similar geographies has been weak livestock pens and corrals prone to predator attacks at night (Wang and Macdonald 2006; Jackson 1999). Dokpa livestock pens are constructed of rocks, making them vulnerable to livestock escape as well as carnivore intrusion (Fig. 8). It is unrealistic for the herders to guard their animals all night especially when the cold desert conditions turn particularly harsh and winter temperatures plummet below zero.

Pastoralists' perception of wildlife plays an important role in the broader sphere of wildlife conservation. Negative perception toward wildlife has been attributed to repeated livestock depredation and sometimes leading to retaliatory killing of wildlife. While we did not observe any evidence of retaliatory killing by Dokpas during our study, Bashir et al. (2018) have reported observations on retaliatory killing while interviewing another Dokpa sub-group in North Sikkim. The *Dzumsa* levies heavy fines as punishment in cases of wildlife crime, including the retaliatory killing of wild carnivores by the Lachen people. Buddhist beliefs that advocate non-violence and the inter-connected nature of all life forms have played a vital role in deterring retaliatory killing in the region.

However, the current belief and attitude of the herders do not guarantee future tolerance, as cases of retaliatory killings have been noted to be an important conservation challenge in geographically and culturally similar landscapes elsewhere (Mishra 1997; Namgail et al. 2007b; Farrington and Tsering 2019). Conservation programmes in the region should engage the pastoralists as partners in conservation and simultaneously address the issue of livestock predation.

#### Addressing the decline of traditional Dokpa pastoralism

In an area that is geo-politically sensitive and ecologically fragile, the *Dokpas* have served as stewards of the landscape and are active participants in managing rangeland resources for themselves and wildlife (Sharma and Dhakal 2011; Ingty 2021). The case of the Dokpa pastoralists of North Sikkim presents two facets to consider when examining the transitory state of pastoralism in North Sikkim: On the one hand, the community-based pasture management model persists due to the presence of the *Dzumsa* system; on the other hand, the actively herding Dokpas, who have worked in tandem with *Dzumsa* governance over hundreds of years to optimise pastoral resource use in North Sikkim, are on the decline. Undoubtedly, the decline in Dokpa pastoralism will lead to, at least in part, the loss of the wealth of traditional ecological knowledge accumulated over several years. The decline in traditional management systems concerning pasture management has been reported to have negatively impacted the biodiversity of rangelands (Thwaites et al. 1998; Xu et al. 2005; You et al. 2013). In the same study site, Ingty (2021) observed increased grassland productivity and vegetation biodiversity in areas where



traditional grazing was carried out compared to ungrazed areas. Thus, the decline of traditional Dokpa pastoralism may negatively impact local rangeland productivity and biodiversity.

Nori and Davies (2007) call for relaxation on marginalised pastoral groups’ social, economic and political constraint to facilitate pastoralists’ adaptive strategies in the face of climatic, social and political changes. In the case of

North Sikkim, these constraints can be addressed by creating a *facilitative environment* (Hogg 1992) for the Dokpas through the construction of predator-proof corals, implementation of dog sterilisation programme, provision of supplementary winter feed, construction of fences around minefields and improved compensation machinery with the local and regional formal and informal institutions (Fig. 9). Policies and programmes should aim to equip the

Dokpa community with actualised economic freedom by increasing their pricing power and value-adding to their livestock-based products. It is only when such an environment is created that pastoralists can continue their livelihoods and begin to cultivate a net positive outlook towards conservation — an element that is vital for conservation work involving community participation.

## Conclusion

Our study provides an overview of the current pastoral practices and their social, political and ecological stressors in North Sikkim. The Dokpa herders and the local institution of *Dzumsa* play a valuable role in adaptive resource management in the Trans-Himalayan rangelands of North Sikkim. It is a unique case of pastoralism and rangeland management where an external institution plays a key role in managing livestock and the pastoralists have adapted a distinct resource use due to loss of traditional pastures. Fragmentation of pastures due to geo-politics, changing local aspirations, livestock loss to predators and climatic events and lack of institutional support are the main factors transforming *Dokpa* pastoral practices. Even after numerous events of livestock depredation, a majority of the *Dokpas* exhibit a positive attitude towards wildlife and conservation initiatives. The decline of actively herding *Dokpas* and the associated loss of traditional knowledge systems could have severe implications for wildlife and rangeland conservation. Conservation and allied organisations should work towards supporting the well-being and livelihood of *Dokpas*, building a self-sustaining rangeland conservation programme, empowering pastoralists and creating a facilitative environment for the continued survival of pastoralism in the rangelands of North Sikkim. Measures such as the provision of alternative fuel sources, construction of predator-proof corrals, proper delineation of minefields, scientific pasture improvement initiatives and implementation of dog sterilisation programmes highlighted in the paper can be undertaken. Better access to healthcare and insurance services for both *Dokpas* and their livestock should be established. Participatory conservation programmes promoting *Dokpas* as primary actors and stewards of rangelands should be established to reconcile local livelihoods with wildlife conservation objectives.

## Acknowledgements

We sincerely thank the Forest, Environment and Wildlife Department, Government of Sikkim, for their cooperation and support. Phuchung Lachenpa is thanked for his help and support in the field with logistics, assistance during the fieldwork and helping with the language translations. We are grateful to all the respondents for their interest, inputs and participation in this study.

## Authors' contributions

NL conducted the fieldwork, analysed the data and wrote the manuscript. RS conceived the study, designed the study, provided guidance for the fieldwork and wrote the manuscript. LT and PS provided critical inputs at the study design and writing stage. RKS provided overall guidance in the study design, data collection and manuscript writing. All the authors edited and approved the final manuscript.

## Funding

This research has been funded by WWF-India.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

All the respondents were informed about the research and a prior oral consent was taken before interviews.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

### Author details

<sup>1</sup>World Wide Fund for Nature (WWF), New Delhi, India. <sup>2</sup>School of Human Ecology, Ambedkar University Delhi, Delhi, India.

Received: 21 December 2021 Accepted: 1 August 2022

Published online: 02 September 2022

## References

- Acharya, Bhoj Kumar, and Sharma Ghanashyam. 2012. The traditional Dzumsa system and their role in resource management in cultural landscape in North Sikkim. In *Cultural landscapes*, ed. P.S. Ramakrishnan, K.G. Saxena, K.S. Rao, and G. Sharma, 175–186. New Delhi: K. S. Rao, National Institute of Ecology.
- AFP. 2019. *300 Himalayan yaks starve to death in Sikkim. The Hindu, May 12, sec. Other states.*
- Agrawal, Arun. 2008. *The role of local institutions in adaptation to climate change.* World Bank. <https://doi.org/10.1596/28274>.
- Animal Husbandry Statistics Division. 2012. *19th livestock Census District-wise report 2012. Volume II.* New Delhi: Ministry of Fisheries, Animal Husbandry & Dairying.
- Aryal, Achyut, Dianne Brunton, Weihong Ji, Rosemary K. Barraclough, and David Raubenheimer. 2014a. Human–carnivore conflict: Ecological and economical sustainability of predation on livestock by snow leopard and other carnivores in the Himalaya. *Sustainability Science* 9: 321–329. <https://doi.org/10.1007/s11625-014-0246-8>.
- Aryal, Suman, Tek Narayan Maraseni, and Geoff Cockfield. 2014b. Sustainability of transhumance grazing systems under socioeconomic threats in Langtang. *Nepal. Journal of Mountain Science* 11: 1023–1034. <https://doi.org/10.1007/s11629-013-2684-7>.
- Bagchi, S., and C. Mishra. 2006. Living with large carnivores: Predation on livestock by the snow leopard (*Uncia uncia*). *Journal of Zoology* 268: 217–224. <https://doi.org/10.1111/j.1469-7998.2005.00030.x>.
- Bagchi, Sumanta, Charudutt Mishra, and Y.V. Bhatnagar. 2004. Conflicts between traditional pastoralism and conservation of Himalayan ibex (*Capra sibirica*) in the trans-Himalayan mountains. *Animal Conservation* 7: 121–128. <https://doi.org/10.1017/S1367943003001148>.
- Bashir, Tawqir, Tapajit Bhattacharya, Kamal Poudyal, and Sambandam Sathyakumar. 2018. Preliminary observations on the cryptic fauna of Sikkim trans-Himalaya, India. *International Journal of Conservation Science* 9: 179–184.



- Berkes, Fikret. 2004. Rethinking community-based conservation. *Conservation Biology* 18: 621–630. <https://doi.org/10.1111/j.1523-1739.2004.00077.x>.
- Bhasin, Veena. 2011. Pastoralists of Himalayas. *Journal of Human Ecology* 33: 147–177.
- Bhattacharya, Sumana, Srinivas Krishnaswamy, and C.K. Rao. 2012. Vulnerability of Sikkim to climate change and strategies for adaptation. In *Climate change in Sikkim: Patterns, impacts and initiatives*, ed. M.L. Arrawatia and S. Tambe, 317. Sikkim: IPR Deptt. Govt. of Sikkim.
- Brown, C.W. 1987. Ecology, trade and former Bhotia identity. In *The Himalayan heritage*, ed. M.K. Raha, 125–137. Delhi: Gian Publishing House.
- Chanchani, Pranav, Gopal S. Rawat, and Surendra P. Goyal. 2010. Unveiling a wildlife haven: Status and distribution of four trans-Himalayan ungulates in Sikkim, India. *Oryx* 44: 366–375. <https://doi.org/10.1017/S0030605310000293>.
- Chaudhuri, Ajit. 2000. Change in Changthang: To stay or to leave? *Economic and Political Weekly* 35: 52–58.
- Chetri, Madhu, Morten Odden, Olivier Devineau, and Per Wegge. 2019. Patterns of livestock depredation by snow leopards and other large carnivores in the Central Himalayas, Nepal. *Global Ecology and Conservation* 17: e00536. <https://doi.org/10.1016/j.gecco.2019.e00536>.
- Chophyel, P. 2009. *Rangeland management in Bhutan: A consultancy report*. Thimphu: Ministry of Agriculture, Royal Government of Bhutan.
- Clemens, Jürgen, and Marcus Nüsser. 2000. Pastoral management strategies in transition: Indications from the Nanga Parbat region (NW Himalaya). In *High mountain pastoralism in northern Pakistan*, ed. Eckart Ehlers and Hermann Kreutzmann, 151–187. Stuttgart: F. Steiner Erdkundliches Wissen Heft 132.
- Dong, Shikui, and Yan Zhaoli. 2016. Institutionalising transboundary grassland resource management for sustainable yak production in the border areas between China and Nepal. In *Yak on the move: Transboundary challenges and opportunities for yak raising in a changing Hindu Kush Himalayan region*, ed. Wu Ning, Yi Shaoliang, Srijana Joshi, and Neha Bisht, 123. Kathmandu: ICIMOD.
- FAO. 2001. *Pastoralism in the new millennium. FAO animal production and health paper 150*. Rome: FAO.
- Farooquee, Nehal A. 1998. Development and the eradication of traditional resource use practice in the central Himalayan transhumant pastoral society. *International Journal of Sustainable Development and World Ecology* 5: 43–50. <https://doi.org/10.1080/13504509809469968>.
- Farrington, John D., and Dawa Tsering. 2019. Human-snow leopard conflict in the Chang tang region of Tibet, China. *Biological Conservation* 237: 504–513. <https://doi.org/10.1016/j.biocon.2019.07.017>.
- Fernandez-Gimenez, Maria E. 2000. The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. *Ecological Applications* 10: 1318–1326.
- Fratkin, Elliot, and Eric Abella Roth. 1990. Drought and economic differentiation among Ariaal pastoralists of Kenya. *Human Ecology* 18: 385–402. <https://doi.org/10.1007/BF00889464>.
- Füssel, Hans-Martin. 2010. How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: A comprehensive indicator-based assessment. *Global Environmental Change* 20: 597–611. <https://doi.org/10.1016/j.gloenvcha.2010.07.009>.
- Galvin, Kathleen A. 2009. Transitions: Pastoralists living with change. *Annual Review of Anthropology* 38: 185–198. <https://doi.org/10.1146/annurev-anthro-091908-164442>.
- Gentle, Popular, and Rik Thwaites. 2016. Transhumant pastoralism in the context of socioeconomic and climate change in the mountains of Nepal. *Mountain Research and Development* 36: 173–182. <https://doi.org/10.1659/MRD-JOURNAL-D-15-00011.1>.
- Gentle, Popular, Rik Thwaites, Digby Race, and Kim Alexander. 2014. Differential impacts of climate change on communities in the middle hills region of Nepal. *Natural Hazards* 74: 815–836. <https://doi.org/10.1007/s11069-014-1218-0>.
- Global Drylands Imperative. 2003. *Pastoralism and mobility in drylands Challenge Paper*. New York: UNCCD.
- Gooch, Pernille. 1992. Transhumant pastoralism in northern India: The Gujjar case. *Nomadic Peoples* 30: 84–96.
- Gooch, Pernille. 2004. Van Gujjar: The persistent forest pastoralists. *Nomadic Peoples, New Series* 8: 125–135.
- Habib, Bilal, S. Shrotriya, and Y.V. Jhala. 2013. *Ecology and conservation of Himalayan wolf. TR-2013/01*. Dehradun: Wildlife Institute of India.
- Hardin, Garrett. 1968. The tragedy of the commons. *Science* 162: 1243–1248. <https://doi.org/10.1126/science.162.3859.1243>.
- Hogg, Richard. 1992. Should pastoralism continue as a way of life? *Disasters* 16: 131–137. <https://doi.org/10.1111/j.1467-7717.1992.tb00386.x>.
- Ingti, Tenzing. 2017. High mountain communities and climate change: Adaptation, traditional ecological knowledge, and institutions. *Climatic Change* 145: 41–55. <https://doi.org/10.1007/s10584-017-2080-3>.
- Ingti, Tenzing. 2021. Pastoralism in the highest peaks: Role of the traditional grazing systems in maintaining biodiversity and ecosystem function in the alpine Himalaya. Edited by Bhoj Kumar Acharya. *PLoS One* 16: e0245221. <https://doi.org/10.1371/journal.pone.0245221>.
- International Livestock Research Institute (ILRI), International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), and International Land Coalition (ILC). 2021. *Rangeland atlas*. Nairobi: ILRI.
- IPCC. 2001. *Climate change 2001: The scientific basis. Contribution of working group I to the third assessment report of the intergovernmental panel on climate change*. Cambridge: Cambridge University Press.
- Jackson, Rodney. 1999. Snow leopard, local people and livestock losses. *CAT news* 31: 22–23.
- Jackson, Rodney. 2012. Fostering community-based stewardship of wildlife in Central Asia: Transforming snow leopards from pests into valued assets. In *Rangeland stewardship in Central Asia*, ed. Victor Squires, 357–380. Dordrecht: Springer Netherlands. [https://doi.org/10.1007/978-94-007-5367-9\\_15](https://doi.org/10.1007/978-94-007-5367-9_15).
- Jackson, Rodney, and Rinchen Wangchuk. 2001. Linking snow leopard conservation and people-wildlife conflict resolution: Grassroots measures to protect the endangered snow leopard from herder retribution. *Endangered Species Update* 18: 138–141. *местные меры по защите снежных барсов от мер воздействия со стороны пастухов ...*
- Jackson, Rodney M., Gary G. Ahlborn, Gurung Mahesh, and Som Ale. 1996. Reducing livestock depredation losses in the Nepalese Himalaya. In *Proceedings of the vertebrate Pest conference 1996*, 241–247.
- Jacquesson, Svetlana. 2010. Reforming pastoral land use in Kyrgyzstan: From clan and custom to self-government and tradition. *Central Asian Survey* 29: 103–118. <https://doi.org/10.1080/02634931003765571>.
- Jamtsho, Yonten, and Om Katel. 2019. Livestock depredation by snow leopard and Tibetan wolf: Implications for herders' livelihoods in Wangchuck centennial National Park. *Bhutan. Pastoralism* 9: 1. <https://doi.org/10.1186/s13570-018-0136-2>.
- Jasra, Abdul Wahid, Maaz Maqsood Hashmi, Kanwal Waqar, and Mastan Ali. 2016. Traditional yak herding in high-altitude areas of Gilgit-Baltistan, Pakistan: Transboundary and biodiversity conservation challenges. In *Yak on the move: Transboundary challenges and opportunities for yak raising in a changing Hindu Kush Himalayan region*, ed. Wu Ning, Yi Shaoliang, Srijana Joshi, and Neha Bisht, 41. Kathmandu: ICIMOD.
- Karanth, Ullas K., and M.D. Madhusudhan. 2002. Mitigating human-wildlife conflicts in southern Asia. In *Making parks work: Strategies for preserving tropical nature*, ed. J. Terborgh, C. Van Schaik, L. Davenport, and M. Rao, 250–264. Washington, D.C.: Island Press.
- Krätli, Saverio, and Nikolaus Schareika. 2010. Living off uncertainty: The intelligent animal production of dryland pastoralists. *The European Journal of Development Research* 22: 605–622. <https://doi.org/10.1057/ejdr.2010.41>.
- Kreutzmann, Hermann. 2012. Pastoral practices in transition: Animal husbandry in high Asian contexts. In *Pastoral practices in high Asia*, ed. Hermann Kreutzmann, 1–29. Dordrecht: Springer Netherlands. [https://doi.org/10.1007/978-94-007-3846-1\\_1](https://doi.org/10.1007/978-94-007-3846-1_1) Advances in Asian Human-Environmental Research.
- Lenaiyasa, Michael Lugard, Brett L. Bruyere, Jonathan Salerno, and Tomas Pickering. 2020. Pastoralists' use of income diversification as a strategy for adapting to social-ecological change in Samburu, Kenya. *Regional Environmental Change* 20: 21. <https://doi.org/10.1007/s10113-020-01612-x>.
- Li, Juan, and Lu. Zhi. 2014. Snow leopard poaching and trade in China 2000–2013. *Biological Conservation* 176: 207–211. <https://doi.org/10.1016/j.biocon.2014.05.025>.
- Little, Peter D. 1985. Social differentiation and pastoralist sedentarization in northern Kenya. *Africa*, 55(3), 243–261. <https://doi.org/10.2307/1160579>
- Macchi, Mirjam, A.M. Gurung, B. Hoermann, and D. Chaudhury, eds. 2011. *Climate variability and change in the Himalayas: Community perceptions*

- and responses. Kathmandu: International Centre for Integrated Mountain Development.
- Miller, D.J. 1998. Nomads of the Tibetan plateau rangelands in Western China part one: Pastoral history. *Rangelands* 20: 24–29.
- Miller, D.J., and B. George. 1996. Schaller. *Rangelands of the Chang Tang Wildlife Reserve in Tibet* 18: 91–96.
- Mishra, Charudutt. 1997. Livestock depredation by large carnivores in the Indian trans-Himalaya: Conflict perceptions and conservation prospects. *Environmental Conservation* 24: 338–343.
- Mishra, Charudutt, Sipke E. Van Wieren, Pieter Ketner, Ignas M.A. Heitkonig, and Herbert H.T. Prins. 2004. Competition between domestic livestock and wild bharal *Pseudois nayaur* in the Indian trans-Himalaya. *Journal of Applied Ecology* 41: 344–354. <https://doi.org/10.1111/j.0021-8901.2004.00885.x>.
- Mittermeier, Russell A., ed. 2004. *Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions. 1. Engl. Ed.* Mexico: CEMEX.
- Mworia, J.K., and J.I. Kinyamario. 2008. Traditional strategies used by pastoralists to cope with La Niña induced drought in Kajiado, Kenya. *African Journal of Environmental Science and Technology* 2: 010–014.
- Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A.B. da Fonseca, and Jennifer Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858. <https://doi.org/10.1038/35002501>.
- Namgail, Tsewang, Yash Veer Bhatnagar, Charudutt Mishra, and Sumanta Bagchi. 2007. Pastoral nomads of the Indian Changthang: Production system, landuse and socio-economic changes. *Human Ecology* 35: 497–504. <https://doi.org/10.1007/s10745-006-9107-0>.
- Namgail, Tsewang, Joseph L. Fox, and Yash Veer Bhatnagar. 2007a. Habitat shift and time budget of the Tibetan argali: The influence of live-stock grazing. *Ecological Research* 22: 25–31. <https://doi.org/10.1007/s11284-006-0015-y>.
- Namgail, Tsewang, Joseph L. Fox, and Yash Veer Bhatnagar. 2007b. Carnivore-caused livestock mortality in trans-Himalaya. *Environmental Management* 39: 490–496. <https://doi.org/10.1007/s00267-005-0178-2>.
- Namgay, Kuenga, Joanne Millar, Rosemary Black, and Tashi Samdup. 2013. Transhumant agro-pastoralism in Bhutan: Exploring contemporary practices and socio-cultural traditions. *Pastoralism: Research, Policy and Practice* 3: 13. <https://doi.org/10.1186/2041-7136-3-13>.
- Niamir, Maryam. 1990. *Community forestry: Herders' decision-making in natural resources management in arid and semi-arid Africa*. Rome: Food and Agriculture Organization of the UN.
- Niamir, Maryam, et al. 1995. Indigenous systems of natural resource management among pastoralists of arid and semi-arid Africa. In *The cultural dimension of development: Indigenous knowledge systems*, 245–257. United Kingdom: Intermediate Technology Publications Ltd (ITP).
- Ning, Wu, Krishna P. Oli, Hammad Gilani, Srijana Joshi, and Neha Bisht. 2016. Yak raising challenges: Transboundary issues in far eastern Nepal. In *Yak on the move: Transboundary challenges and opportunities for yak raising in a changing Hindu Kush Himalayan region*, ed. Wu Ning, Yi Shaoliang, Srijana Joshi, and Neha Bisht, 53. Kathmandu: ICIMOD.
- Nori, M., and J. Davies. 2007. *Change of wind or wind of change?: Climate change, adaptation and pastoralism*. Nairobi: WISP, IUCN.
- Nori, Michele, Jason Switzer, and Alec Crawford. 2005. *Herding on the brink: Towards a global survey of pastoral communities and conflict*. Canada: International Institute for Sustainable Development.
- Oba, G., and D.G. Kotile. 2001. Assessments of landscape level degradation in southern Ethiopia: Pastoralists versus ecologists. *Land Degradation & Development* 12: 461–475.
- Oli, Madan K., Iain R. Taylor, and M. Elizabeth Rogers. 1994. Snow leopard *Panthera uncia* predation of livestock: An assessment of local perceptions in the Annapurna conservation area, Nepal. *Biological Conservation* 68: 63–68. [https://doi.org/10.1016/0006-3207\(94\)90547-9](https://doi.org/10.1016/0006-3207(94)90547-9).
- Oli, Krishna Prasad, Sunita Chaudhary, and Uday Raj Sharma. 2013. Are governance and management effective within protected areas of the Kanchenjunga landscape (Bhutan, India and Nepal)? *PARKS* 19: 25–36. <https://doi.org/10.2305/IUCN.CH.2013.PARKS-19-1.KPO.en>.
- Pantuliano, Sara. 2010. Oil, land and conflict: The decline of Misseriyya pastoralism in Sudan. *Review of African Political Economy* 37: 7–23 Taylor & Francis.
- Rahman, H., R. Karuppaiyan, P.C. Senapati, S.V. Ngachan, and Ashok Kumar. 2012. An analysis of past three decade weather phenomenon in the mid-hills of Sikkim and strategies for mitigating possible impact of climate change on agriculture. In *Climate change in Sikkim: Patterns, impacts and initiatives*, ed. M.L. Arrawatia and Sandeep Tambe, 19. Sikkim: IPR Deptt. Govt. of Sikkim.
- Sahlins, P., and J.C. Scott. 2001. *Official and vernacular identifications in the making of the modern world* American Council for Learned Societies Collaborative Research Network [Online].
- Salzman, Philip Carl. 1999. Is inequality universal? *Current Anthropology* 40: 31–61. <https://doi.org/10.1086/515800>.
- Sharma, Ghanashyam, and T. Dhakal. 2011. Opportunities and challenges of the globally important traditional agriculture heritage systems of the Sikkim Himalaya. In *Biodiversity of Sikkim: Exploring and conserving a global hotspot*, ed. Murari Arrawatia and Sandeep Tambe, 379–402. Gangtok: Information and Public Relations Department, Government of Sikkim.
- Sharma, V., I. Köhler-Rollefson, and John Morton. 2003. *Pastoralism in India: A scoping study*. New Delhi: Department for International Development.
- Sharma, Ghanashyam, Sandeep Tambe, Gopal Singh Rawat, and Murari Lal Arrawatia. 2016. Yak herding and associated transboundary issues in the Sikkim Himalaya, India. In *Yak on the move: Transboundary challenges and opportunities for yak raising in a changing Hindu Kush Himalayan region*, ed. Wu Ning, Yi Shaoliang, Srijana Joshi, and Neha Bisht, 93. Kathmandu: ICIMOD.
- Shrestha, Rinjan, and Per Wegge. 2008. Wild sheep and livestock in Nepal trans-Himalaya: Co-existence or competition? *Environmental Conservation* 35: 125–136. <https://doi.org/10.1017/S0376892908004724>.
- Shrestha, Rinjan, Per Wegge, and Rita A. Koirala. 2005. Summer diets of wild and domestic ungulates in Nepal Himalaya. *Journal of Zoology* 266: 111–119. <https://doi.org/10.1017/S0952836905006527>.
- Singh, Navinder J., Yash Bhatnagar, Nicolas Lecomte, Joseph L. Fox, and Nigel G. Yoccoz. 2013. No longer tracking greenery in high altitudes: Pastoral practices of Rupshu nomads and their implications for biodiversity conservation. *Pastoralism: Research, Policy and Practice* 3: 16. <https://doi.org/10.1186/2041-7136-3-16>.
- Singh, Rashmi, Rishi Kumar Sharma, and Suresh Babu. 2015. Pastoralism in transition: Livestock abundance and herd composition in Spiti, trans-Himalaya. *Human Ecology* 43: 799–810. <https://doi.org/10.1007/s10745-015-9789-2>.
- Singh, Rashmi, Rishi Kumar Sharma, Suresh Babu, and Yash Veer Bhatnagar. 2020. Traditional ecological knowledge and contemporary changes in the agro-pastoral system of upper Spiti landscape, Indian trans-Himalayas. *Pastoralism* 10: 1–14.
- Singh, Rashmi, Rishi Kumar Sharma, Tsering Uden Bhutia, Kinzong Bhutia, and Suresh Babu. 2021. Conservation policies, eco-tourism, and end of pastoralism in Indian Himalaya? *Frontiers in Sustainable Food Systems* 5: 613998. <https://doi.org/10.3389/fsufs.2021.613998>.
- Singh, Rashmi, Tsering Uden Bhutia, Kinzong Bhutia, and Suresh Babu. 2022. Rangeland conservation, pastoralists displacement and long term implications of a grazing ban in the Indian Himalaya. *Ecology, Economy and Society—the INSEE Journal*. 5 (1) <https://doi.org/10.37773/ees.v5i1.335>.
- Subba, T.B. 1989. Agrarian social structure and change in Sikkim. *Social Change* 19: 80–86.
- Suryawanshi, Kulbhushansingh R., Yash Veer Bhatnagar, Stephen Redpath, and Charudutt Mishra. 2013. People, predators and perceptions: Patterns of livestock depredation by snow leopards and wolves. Edited by Nathalie Pettorelli. *Journal of Applied Ecology* 50: 550–560. <https://doi.org/10.1111/1365-2664.12061>.
- Thwaites, Rik, Terry de Lacy, Li Yong Hong, and Liu Xian Hua. 1998. Property rights, social change, and grassland degradation in Xilingol biosphere reserve, Inner Mongolia, China. *Society & Natural Resources* 11: 319–338. <https://doi.org/10.1080/08941929809381085>.
- Tiwari, Krishna Raj, Bishal Kumar Sitaula, Roshan Man Bajracharya, Nani Raut, Prabin Bhusal, and Mukunda Sengel. 2020. Vulnerability of pastoralism: A case study from the high mountains of Nepal. *Sustainability* 12: 2737. <https://doi.org/10.3390/su12072737>.
- Toit, Du, T. Johan, Richard Kock, and James C. Deutsch, eds. 2010. *Wild rangelands: Conserving wildlife while maintaining livestock in semi-arid ecosystems*, Conservation science and practice series no. 6. Oxford, Hoboken: Wiley-Blackwell.
- Wang, Sonam Wangyel, and D.W. Macdonald. 2006. Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation* 129: 558–565.
- Wrobel, Monica L., and Kent H. Redford. 2010. Introduction: A review of rangeland conservation issues in an uncertain future. In *Wild rangelands*, ed.

- Johan T. du Toit, Richard Kock, and James C. Deutsch, 1–12. Chichester: Wiley. <https://doi.org/10.1002/9781444317091.ch1>.
- Wu, Ning, Muhammad Ismail, Srijana Joshi, Shao-liang Yi, Ritu Meher Shrestha, and Abdul Wahid Jasra. 2014. Livelihood diversification as an adaptation approach to change in the pastoral Hindu-Kush Himalayan region. *Journal of Mountain Science* 11: 1342–1355. <https://doi.org/10.1007/s11629-014-3038-9>.
- Xu, Jianchu, Yong Yang, Zhuoqing Li, Nyima Tashi, Rita Sharma, and Jing Fang. 2008. Understanding land use, livelihoods, and health transitions among Tibetan nomads: A case from Gangga township, Dingri county, Tibetan autonomous region of China. *EcoHealth* 5: 104–114. <https://doi.org/10.1007/s10393-008-0173-1>.
- Xu, Jianchu, Erzi T. Ma, Duojie Tashi, Fu Yongshou, Lu Zhi, and David Melick. 2005. Integrating sacred knowledge for conservation: Cultures and landscapes in Southwest China. *Ecology and Society* 10. <https://doi.org/10.5751/ES-01413-100207>.
- You, Zhang Qiang, Zhi Gang Jiang, Chun Wang Li, and David Mallon. 2013. Impacts of grassland fence on the behavior and habitat area of the critically endangered Przewalski's gazelle around the Qinghai Lake. *Chinese Science Bulletin* 58: 2262–2268. <https://doi.org/10.1007/s11434-013-5844-9>.

### Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen<sup>®</sup> journal and benefit from:

- ▶ Convenient online submission
- ▶ Rigorous peer review
- ▶ Open access: articles freely available online
- ▶ High visibility within the field
- ▶ Retaining the copyright to your article

---

Submit your next manuscript at ▶ [springeropen.com](https://www.springeropen.com)

---