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Rethinking climate impacts and livestock emissions through transhumant pastoralism in Jammu and Kashmir

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This article reconsiders the climate implications of transhumant pastoralism through an ethnographic case study of the Chopan pastoralists in the alpine grasslands of Jammu and Kashmir, India. Amid dominant global climate narratives that homogenize livestock systems and often portray them as ecologically harmful, this study highlights the need for differentiated assessments that recognize the distinctiveness of extensive, low-input systems. Drawing on fieldwork conducted in the high-altitude Trajan pasture, we demonstrate how Chopan pastoralism makes ecologically efficient use of marginal environments through adaptive mobility, rotational grazing, and traditional ecological knowledge. Contrary to assumptions of overgrazing and degradation, our analysis—grounded in forage yield estimates and carrying capacity calculations—suggests that current grazing pressure remains well within sustainable limits. Moreover, the Chopans contribute to regional food security, mediate human-wildlife interactions, and promote soil fertility through natural nutrient cycling. Yet, these pastoralists remain structurally marginalized in policy frameworks and face increasing constraints from land-use change, forest restrictions, and infrastructural encroachments. We argue for the inclusion of pastoralist perspectives in climate policy debates and for a revaluation of transhumant systems as viable models of low-impact, climate-resilient land use. The study advances broader discussions on sustainability, ecological justice, and the role of traditional livelihoods in contemporary environmental governance.

KEYWORDS

climate change, transhumant pastoralism, greenhouse gas emissions, Chopan pastoralists, Jammu and Kashmir, livestock emissions, Forest Rights Act (FRA)

Introduction

The debate regarding emissions from livestock production has gained momentum since the UN Food and Agriculture Organization's 2006 report *Livestock's Long Shadow* estimated that 17.8% of greenhouse gas (GHG) emissions came from livestock (Steinfeld et al. 2006). Subsequent assessments have provided varying figures: Gerber et al. (2013) suggested 14.5%, Poore and Nemecek (2018) about 15%, Xu et al. (2021) proposed 19.6%,

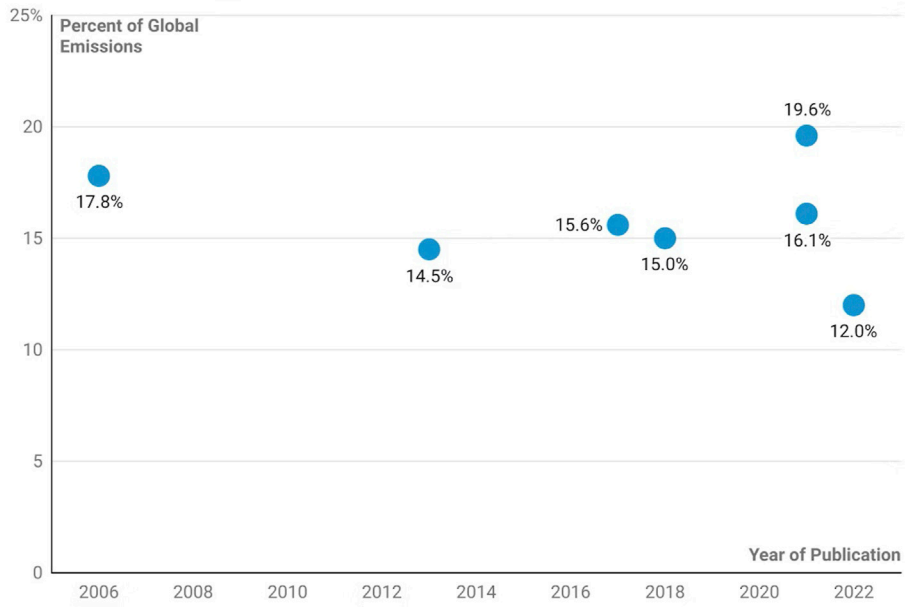

FIGURE 1
Estimated percentages of greenhouse gas emissions from livestock across different studies and years of publication. Adapted from Blaustein-Rejto and Gambino (2023).

while the latest GLEAM 3 estimate indicates 12% which is lower than previous GLEAM estimates (FAO 2023). Figure 1 presents the wide variation in estimates of greenhouse gas emissions from livestock, organized by their respective years of publication. These differences arise primarily from variations in the reference year of measurement, the emission sources included in the analysis, and the methodological approaches used to assess and compare the climate impact of different greenhouse gases (Blaustein-Rejto and Gambino 2023). The most widely cited estimate so far is of Gerber et al. (2013) which says that livestock emissions contribute 14.5% to the global anthropogenic greenhouse gas (GHG) emissions primarily through enteric fermentation producing methane, manure management and land use changes.

Most of the data used in greenhouse gas emission assessments are derived from intensive livestock systems, primarily located in the Global North and other developed regions; however, these assessments have contributed to media narratives that frequently depict pastoralism—an extensive and context-specific livestock system—as environmentally detrimental (Scoones 2023). The narrative advocating for alternatives to animal-based foods is prominently endorsed by influential individuals, including David Attenborough and Greta Thunberg, and is widely disseminated through media channels, while its commercial viability is further reinforced by the support of key actors such as Bill Gates and the World Economic Forum (García-Dory, Houzer, and Scoones 2022). However, such narratives typically fail to differentiate between intensive and extensive livestock systems, overlooking the unique characteristics and potential environmental benefits of traditional pastoralism. The assessments are affected by biases in the data, inconsistencies in how livestock systems are defined, and methodological challenges related to how baselines are established and evaluated within the models (STEPS Centre, 2023). Houser and Ian (2021) have advocated for systems analysis rather than life cycle analysis when calculating emissions from pastoral systems, arguing that mainstream climate policies unjustly portray all livestock systems as harmful while overlooking the low-impact nature and socio-environmental value of pastoralist systems, which leads to systematic marginalization of extensive livestock keepers (García-Dory, Houzer, and Scoones 2022). The most recent FAO report (2023), along with earlier studies, proposes various mitigation strategies, many of which are impractical to implement; those that are applicable are often already embedded within extensive pastoral systems globally. Addressing emission challenges effectively therefore requires the active involvement of pastoral communities and the integration of their traditional knowledge into policy and strategy development.

This study focuses on Chopan pastoralists in Jammu and Kashmir, India, who practice transhumant pastoralism in highland pastures above the tree line. As specialized sheep herders who do not own their own sheep or land, Chopans represent a marginalized community whose practices and

knowledge have been largely absent from climate policy discussions. The prioritization of intensified production systems has historically excluded pastoralist communities—such as the Chopans—who have received limited support from government programs, subsidies, and financial services, thereby raising important questions about the equitable distribution of benefits in the future expansion of alternative and industrial protein sectors, particularly given the state's previous inability to address their needs in ways that also encompass cultural preservation, sustainable livelihoods, food security, and biodiversity protection. Through ethnographic research in the Trajan pasture, we explore how these pastoralists navigate environmental variability, contribute to local food security, and potentially enhance carbon sequestration in alpine grasslands.

The study addresses the research questions that examine the necessity of pastoralism for grasslands, its effects on carrying capacity, its environmental impacts and benefits, alternative land uses for highland pastures, implications of global climate narratives for local pastoral systems, effects on food security, policy impacts on pastoralists and low income countries, mitigation strategies in case of pastoralism, and the importance of indigenous knowledge and the involvement of pastoralists in climate debates.

Livestock emissions and climate change debates

The role of livestock in contributing to greenhouse gas emissions has been widely debated in both scientific and policy domains. While multiple influential studies report that livestock production significantly contributes to global emissions (Steinfeld et al. 2006; Gerber et al. 2013; Poore and Nemecek 2018; Xu et al. 2021), critics have questioned the methodologies used and their applicability across diverse production systems. The discussions need to differentiate between the systems and the situations in developing and industrialized developed countries.

In their critique of Poore and Nemecek (2018) peer-reviewed study, García-Dory, Houzer, and Scoones (2022) acknowledge its comprehensive dataset while highlighting significant limitations. They note that the research predominantly examines industrial agricultural systems in confined settings where free grazing is absent. The data collection demonstrates a distinct geographic bias, drawing primarily from European and North American contexts, with limited representation from Latin America and coastal China. Importantly, traditional subsistence production systems were explicitly excluded from the analysis. A review of 164 food production life cycle analyses revealed that a mere 0.4 percent originated from African contexts, with the vast majority examining industrial systems (Clark and Tilman 2017). The assessments assume that additional livestock result in additional emissions from an assumed neutral baseline, failing to recognize that in extensive systems, alternative land uses may not be possible as crops or trees will not grow and removal of livestock could lead to their replacement by other greenhouse gas-producing animals, whether wild ruminants or termites (Manzano and White 2019).

Research has indicated ecological advantages of extensive pastoral systems across diverse regions. Research in Sardinia, Italy showed that semi-extensive systems have potential benefits over more intensive systems due to the high carbon costs of feed imports and opportunities for carbon sequestration (Arca et al. 2021; Vagnoni et al. 2017). Researchers documented similar findings in China's Amdo Tibet region when extensive and more intensive systems were compared (Zhuang et al., 2017). In Senegal, mobile pastoral systems could achieve carbon neutrality, and occasionally even remove carbon from the atmosphere, when analyzed holistically within their ecological context (Assouma et al. 2019).

Recent studies have also challenged perceptions of particular livestock types. Kerven (2024) argues that the negative climate impact of domestic goats may be overstated, emphasizing their importance for low-income farmers, adaptability to harsh environments, and relatively low methane emissions per unit body weight compared to other ruminants, depending on feed and management systems. Loomis and Kerven (2025) challenge popular narratives of goats as agents of desertification, arguing instead that their ecological adaptability supports the resilience and food security of marginalized pastoralist communities. Dubeuf et al. (2023) highlight goat farming as a sustainable and low-emission livestock system, emphasizing its adaptability, use of marginal resources, and potential for climate impact mitigation through precision practices.

Pastoralism, uncertainty, and development

Pastoralism involves the extensive use of rangelands through mobile livestock-keeping, providing vital livelihoods globally. Rangelands cover more than half the world's land surface, supporting millions of people in harsh and highly variable environments (ILRI, IUCN, FAO, WWF, UNEP, and ILC, 2021). The provision of livestock products, such as meat, milk, wool, hides, and so on, is essential for local economies and the nutrition of often marginalized people (Manzano et al. 2021; Köhler-Rollefson 2021).

Pastoralists practice mobility to access resources, responding to variability and uncertainty (Krätli 2015; Scoones 2021; Manzano et al. 2021). This adaptability is increasingly recognized as valuable in the context of climate change, as pastoralists are well-suited to thrive under conditions of climate variability (Scoones 1995; Davies and Nori 2008; Goldman and Riosmena 2013; Pollini and Galaty 2021; Rodgers 2022; Marty et al. 2023).

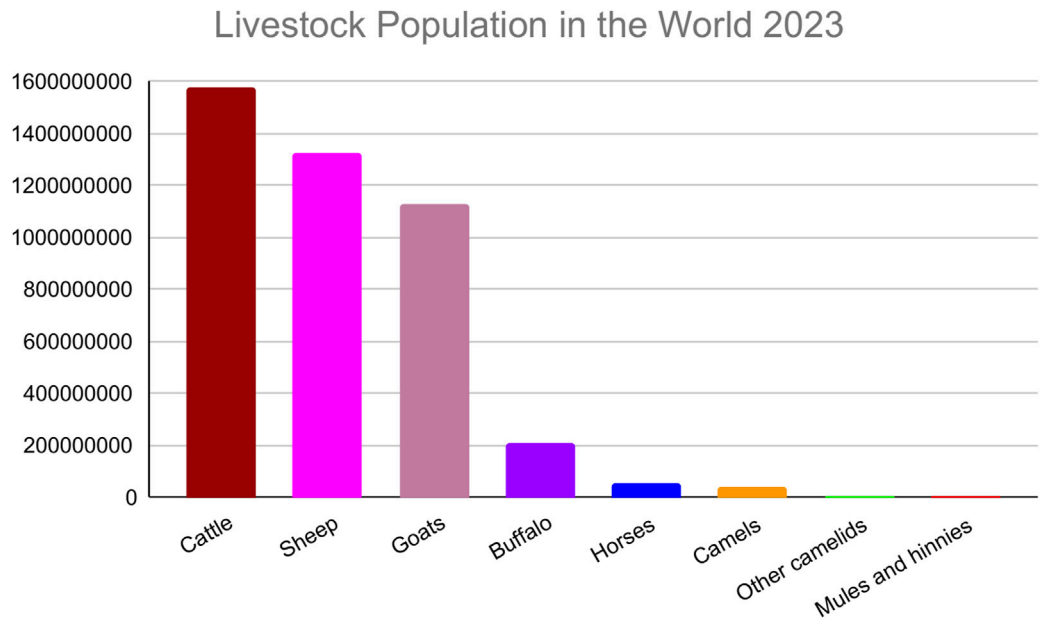

FIGURE 2
Ungulate livestock population in the world 2023. Source: FAOSTAT (2025).

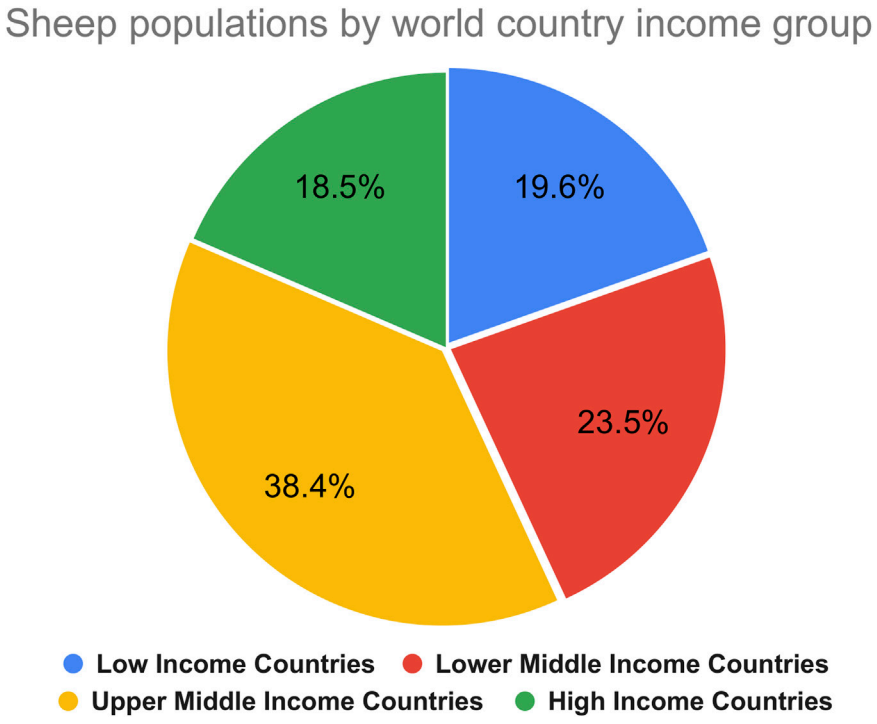

FIGURE 3
Sheep populations by world country income group. Source: World Bank Group (2025), based on gross national income (GNI) *per capita* data in U.S. dollars And FAOSTAT (2025).

Pastoral systems in Jammu and Kashmir

Sheep were among the earliest animals to be domesticated, originating in the Fertile Crescent and subsequently spreading across the globe, where they developed into numerous breeds and became integral to human societies (Zeder and Hesse 2000). The global sheep population is estimated at approximately 1.3 billion, making sheep the second most numerous ungulate livestock after cattle (FAOSTAT 2025) (see Figure 2). A majority of the global sheep population (56.9%) is concentrated in upper-middle- and high-income countries, where intensive livestock farming is predominant; in contrast, extensive pastoral systems are more common in low- and lower-middle-income countries, especially in Africa and Asia (World Bank Group 2025) (see Figure 3).

In Jammu and Kashmir, transhumant pastoralism is practiced by several communities. These include the Gaddis, who rear large flocks of sheep and goats; the Bakarwals, who are nomadic goat herders; the Gujjars, known for rearing buffaloes; and the Chopans, who specialize in sheep herding (Rao and Casimir 1982). The region's alpine and subalpine pastures—locally known as *Margs* or *Bahaks*—are ecologically significant and economically vital resources (Haq et al. 2022; Saleem et al. 2024b).

Rao and Casimir (1982) describe the Chopan as professional herders employed by sedentary agriculturalists in the Kashmir Valley and Jammu plains. They are responsible for livestock management during the summer months, moving animals to high-altitude pastures while owning minimal or no land themselves. Although the herds do not belong to them, the Chopans exercise substantial control over herd management and reproduction. Traditionally paid in kind, they are now predominantly compensated in cash.

The Chopan, the focus of this study, are socioeconomically marginalized sheep herders who manage the flocks of *zamindars* (land-owning farmers or agriculturalists) in the highland pastures between May and October each year. They are one of the many communities in India who have specialized pastoralist identities (Kishore and Köhler-Rollefson 2020; FAO 2021). Despite their central role in traditional pastoral systems, they have not been granted Scheduled Tribe status by the Government of India unlike other pastoral communities in Jammu and Kashmir. Their exclusion from official recognition has contributed to their invisibility in contemporary policy and academic discourse. Even recent studies, such as Singh and Kerven (2023), have omitted the Chopan from analysis, primarily due to underrepresentation in official datasets and limited documentation.

In comparison, Gujjar and Bakarwal pastoralists have received more scholarly attention. Rashid, Ghosh, and Ali (2024) analyze the inter- and intra-community dynamics among these groups, noting that kinship ties, shared cultural practices, and cooperative strategies enable them to adapt to socio-environmental pressures. Similarly, Banka and Sahani (2023) underscore the pressing socio-ecological and policy-related challenges faced by the Chopan, such as inadequate shelter, wildlife threats, reduced access to grazing lands, restrictions on traditional ecological knowledge, and declining economic viability of sheep-based livelihoods.

Methods

Study area

This study was conducted in the Trajan pasture (34°00′28″N 74°20′39″E) in District Baramulla, Jammu and Kashmir, India (see Figure 4). The site lies approximately 6.5 km from the well-known tourist destination of Gulmarg (34°02′58″N 74°23′35″E) and about 3 km from the border between Pakistan-administered (Muzaffarabad) and Indian-administered Kashmir. The pasture ranges in elevation from approximately 3,250 to 4,150 m above sea level and lies above the treeline, featuring a harsh climate marked by highly variable weather, including frequent rainfall and cloud cover. A topographic overview of the landscape is provided in Figure 5.

Due to the pasture's proximity to the border, access required permissions from district administration, police, and military authorities. The terrain is mountainous and challenging to traverse, necessitating a full day's journey on foot from the nearest road.

Data collection

Ethnographic fieldwork was conducted among the Chopan pastoralists, involving participant observation and extended residence with the community—from their home villages to the highland Trajan pasture. The research focused on observing daily herding practices, camp organization, and adaptive strategies employed in response to environmental conditions. Interviews were conducted in Kashmiri, the native language of the Chopan pastoralists, and recorded using a mobile phone recorder. These interviews explored their knowledge, practices, challenges, and perceptions of climate change and policy impacts. Informal focus group discussions (FGDs) provided collective perspectives on pastoralism, climate, and government policies.

Given the unpredictable weather at the fieldsite, with rain and cloud cover occurring anytime during the day, photography was a key tool for data collection. This approach aimed to capture critical moments revealing underlying tensions within uncertain pastoral landscapes and to contribute to broader debates on pastoralism, uncertainty, and development beyond conventional frameworks (Bose and Gogineni 2023). The photographs were also incorporated into the analytical process. Figure 6 presents

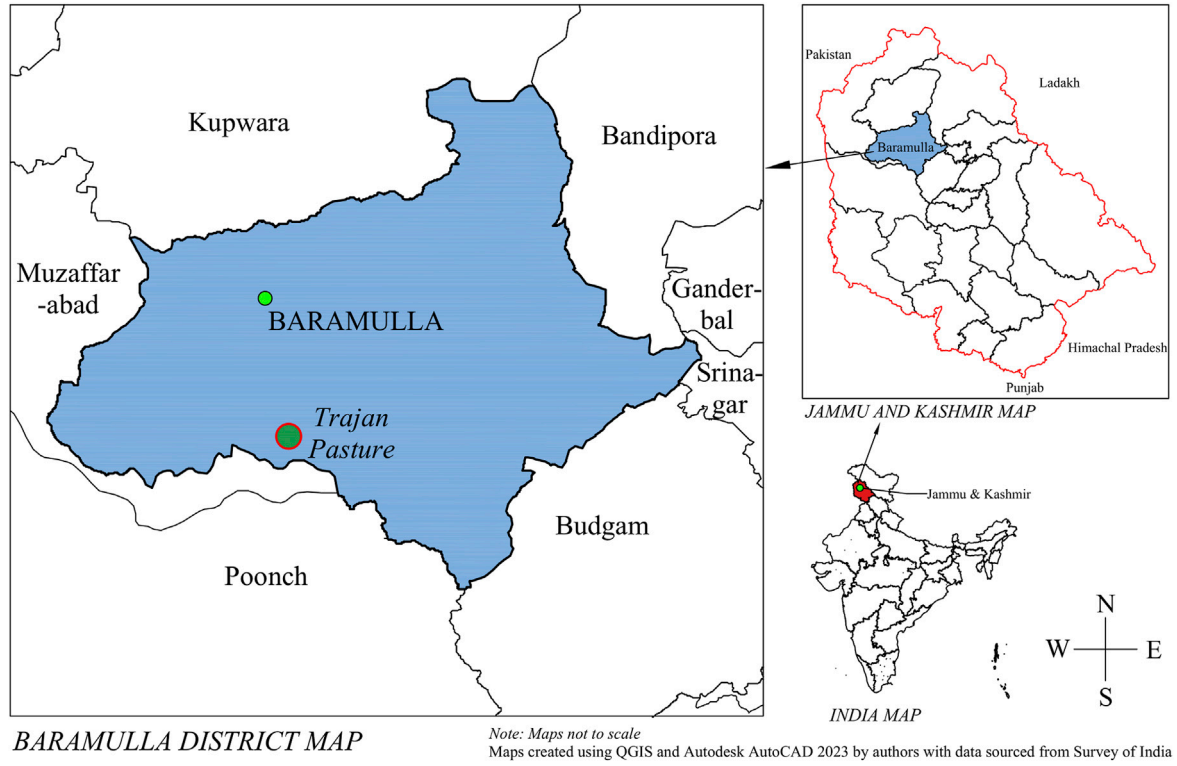

FIGURE 4
Maps showing location of Trajan Pasture (Study Area). Source: Prepared by authors (2025).

selected images taken during fieldwork that illustrate key moments and contextual elements relevant to the study.

The pasture was mapped using pencil and paper in the field, with rough elevations recorded relative to the pastoral camp (Kotha). This was later refined using QGIS and AutoCAD 2023. Mapping was facilitated by one author's prior land surveying experience. Data for mapping was obtained manually, and elevations for contour lines were supplemented by secondary sources, including Google Earth, topographic maps, and Survey of India.

Due to limitations in conducting direct biomass sampling, forage availability in Trajan was estimated using data from the Diskel pasture (33.8324°N, 74.5550°E), approximately 20 km away and ecologically similar. According to Saleem et al. (2024a), Diskel has an average dry forage yield of 3.88 metric tons per hectare.

We acknowledge that this approach introduces a limitation in precision, as variations in microclimate and grazing history between the two sites may influence forage yield. Future studies would benefit from on-site biomass sampling to improve accuracy and allow for sensitivity analysis.

Existing literature on livestock emissions, pastoralism, and climate change was reviewed to contextualize field observations and address research questions. The study focused on four Chopan groups at the Trajan site, belonging to the villages of Morishpora, Burzawacchan, and Khushi Pora, all in district Baramulla. These groups comprised seven individuals managing a total of 2,650 sheep over the 860.9-ha area of Trajan pasture. One group had relocated from the nearby Khilan pasture in July to rest their home pasture.

Data analysis

Data collected through field notes, interview transcripts, and focus group discussions were analyzed thematically to identify patterns related to pastoral practices, environmental knowledge, adaptation strategies, challenges, and perceptions of climate policies. Photographs captured during fieldwork were integrated into this process to visually interpret pastoral routines, material conditions, and moments of uncertainty. These images functioned as ethnographic tools, offering insight into the affective and embodied dimensions of Chopan pastoral life that are often less accessible through textual data alone.

To understand spatial patterns of movement and resource use within the pasture, maps and spatial data were analyzed. The area of the field site—Trajan pasture—was calculated to be approximately 8.609 square kilometers, with a perimeter of 12.597 km, using AutoCAD 2023.

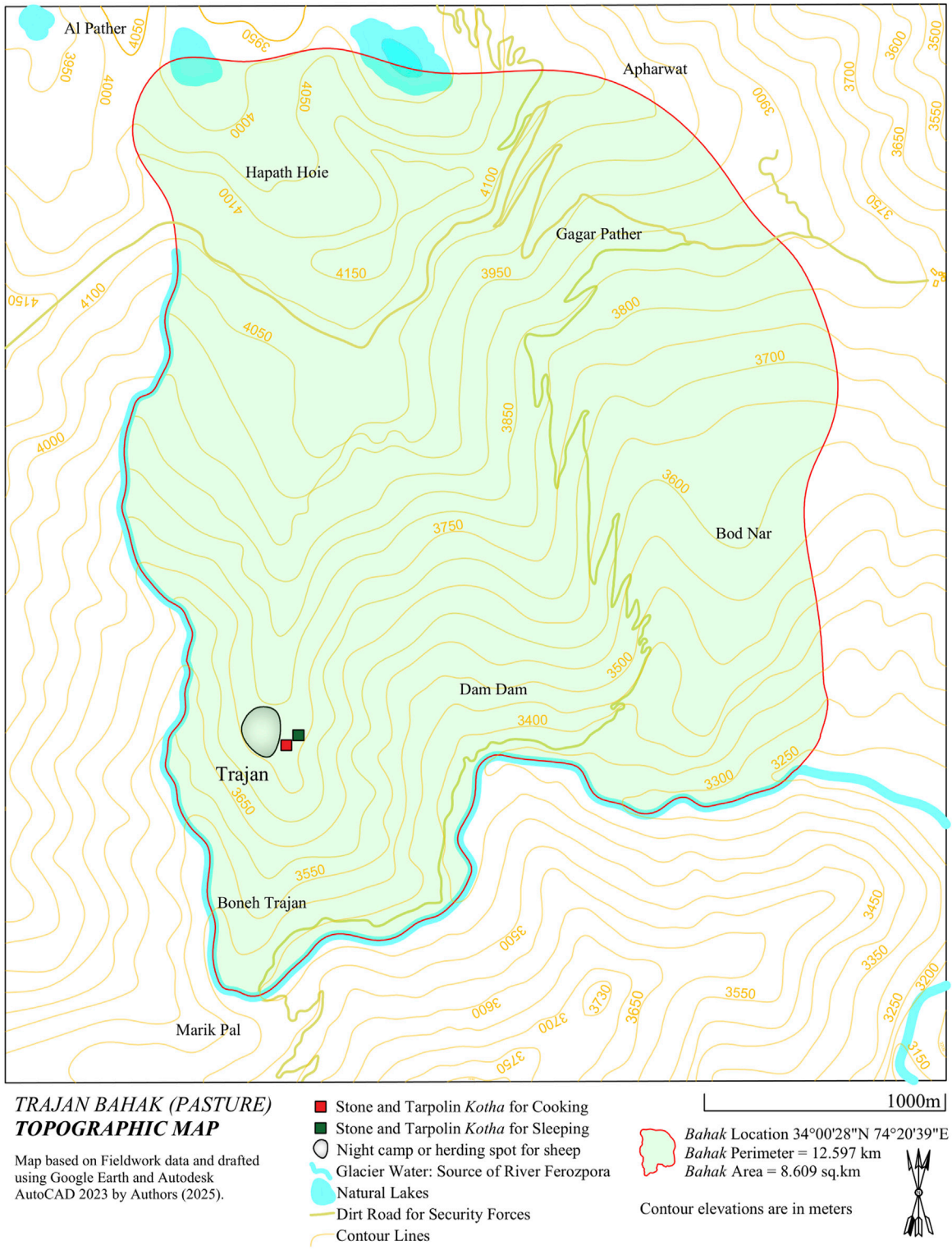

FIGURE 5
Topographic Map of the Trajan Pasture (Field Site). Source: Prepared by authors (2025).

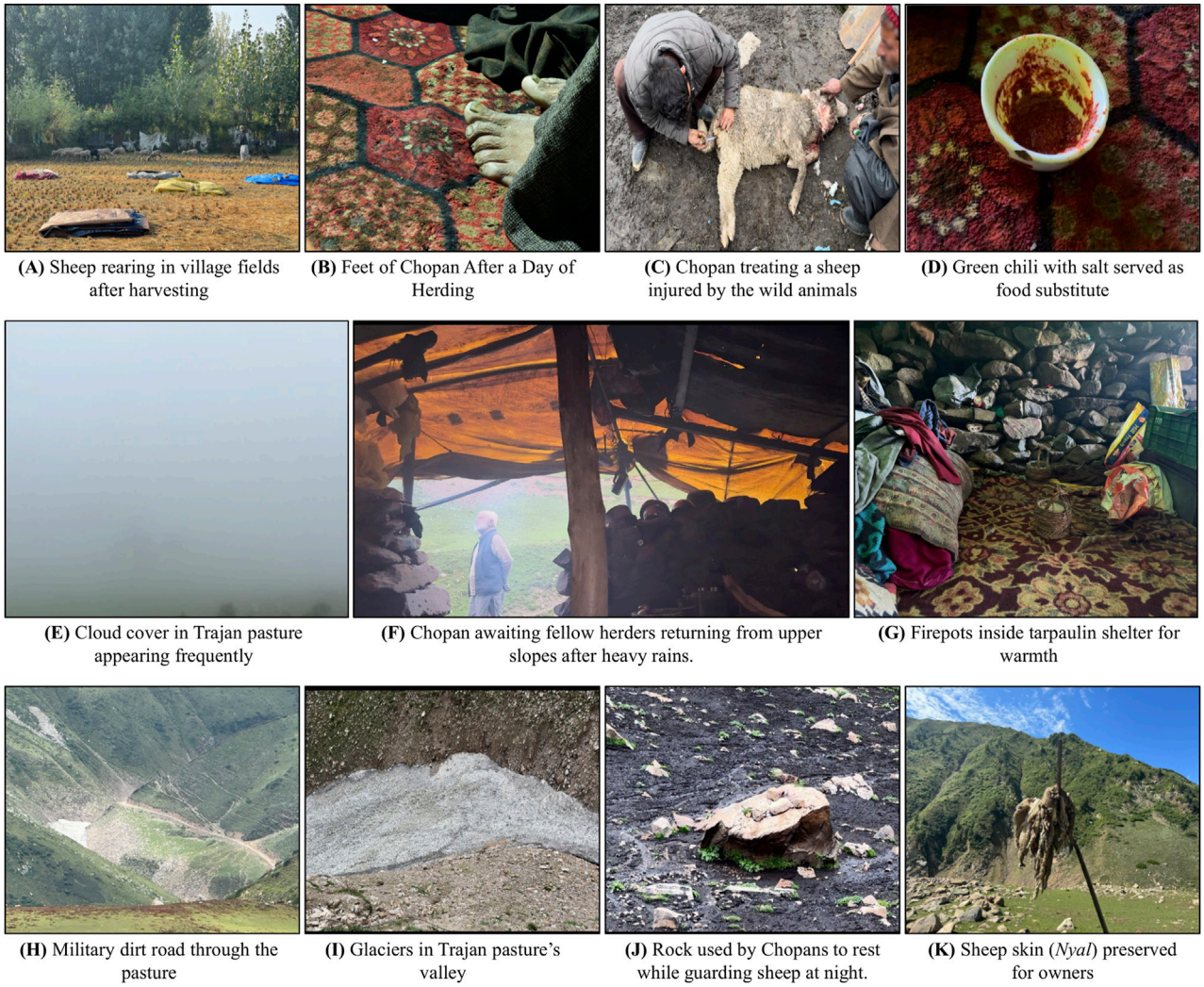

FIGURE 6
Photographic documentation **(A–K)** of pastoral life and uncertainty in the highland pastures of Kashmir. **(A)** Sheep graze in village fields post-harvest. **(B)** Close-up of a Chopan's feet on a patterned rug after a day of herding. **(C)** Chopan treats a sheep injured by wildlife. **(D)** Chili powder with salt in a cup served as food substitute to the researcher. **(E)** Cloud cover in Trajan pasture appearing frequently. **(F)** Chopan awaiting fellow herders returning from upper slopes after heavy rains. **(G)** Firepots in a stone-walled tarp shelter. **(H)** Military dirt road through the pasture. **(I)** Glaciers in Trajan pasture's valley. **(J)** Rock used by Chopans to rest while guarding sheep at night. **(K)** Sheep skin (Nyal) hung on a wooden pole, preserved for owners. Source: Fieldwork by author in 2024.

Carrying capacity and grazing pressure were estimated using rangeland management frameworks. Following established practice, a 50% utilization rate was applied to reflect the proportion of forage available for livestock use (Holechek 1988; Saleem et al. 2024a), resulting in an estimated usable forage of 1,940 kg per hectare. One animal unit (AU) was defined as a sheep with an average body weight of 52 kg, requiring 1.3 kg of dry matter per day—about 2.5% of its body weight. Based on a 50-day grazing season—aligned with the grass renewal cycle—each sheep was estimated to consume 65 kg of forage.

The carrying capacity (CC), representing the number of animals the pasture can sustainably support, was calculated using the formula:

$$CC = \frac{Usable\ Forage}{Forage\ Requirement\ per\ AU}$$

The stocking rate (SR) was computed by dividing the total number of sheep by the pasture area. The carrying rate (CR) was then derived by taking the ratio of the stocking rate to the carrying capacity.

Analysis of government data on livestock populations, meat production, and consumption in Jammu and Kashmir

supplemented the ethnographic data to contextualize local pastoral practices within broader regional trends.

Reflexivity and scope

None of the authors belong to the Chopan or any other pastoralist community. However, the first two authors are from the Himalayan region and have worked closely with transhumant groups in Jammu and Kashmir since 2019. Fieldwork among Chopan herders was carried out during their seasonal migrations, with trust built over time through extended stays in high-altitude pastures and regular participation in daily routines. While the authors are not part of the community, their regional familiarity and sustained engagement supported meaningful dialogue and mutual respect.

This position—neither fully inside nor fully outside—shaped how the research was conducted and how the findings were interpreted. It required careful reflection on power, access, and responsibility, especially in a politically sensitive setting like Jammu and Kashmir. Ethical considerations such as confidentiality, informed consent, and sensitivity to local risks were central throughout the research process. The study aims to reflect the voices and experiences of Chopan pastoralists while also critically examining the institutional systems that affect their lives.

The scope of this study is intentionally narrow. It focuses on one pastoral group—the Chopans—and a single alpine pasture, Trajan, located in Baramulla District. The findings are not presented as representative of all pastoralist communities in the Himalayas. Instead, this case offers an in-depth example of how transhumant pastoralism can operate as an environmentally sustainable and socially important way of life in high-altitude settings.

The analysis is based on detailed conversations with seven Chopan herders. While this small sample is consistent with qualitative ethnographic research, it limits broader generalisations. The aim here is to offer insight rather than statistical conclusions. Future studies comparing different pastoral groups and landscapes would help build a fuller picture and guide more inclusive and context-aware policies.

This study contributes to that larger conversation by showing how local knowledge, mobility, and land use practices are tied to broader issues of climate policy, ecological sustainability, and social marginalisation.

Results

Pastoral practices and knowledge systems

In Kashmir, the Chopan pastoralists—locally referred to as *Pahael* (singular: *Pohol*)—practice transhumant pastoralism, moving seasonally between lowland villages and highland pastures. Preparations begin in March when *Zamindars* (landowning agriculturalists) entrust their sheep to the Chopans. The pastoralists refer to this seasonal movement as *bahakih khason*, meaning "moving up to the highland pasture," while *Zamindars* describe it as *nyor sozun*, or "sending sheep to pasture."

For approximately 6 weeks, the sheep are grazed on village outskirts and uncultivated fields. By May, as temperatures rise and lowland conditions become unsuitable, Chopans initiate their upward migration toward alpine pastures. The timing of this movement is influenced by snowmelt in the highlands and irrigation cycles in the lowlands. Warmer temperatures in the villages can negatively impact sheep health, prompting even stall-based intensive livestock owners to send their animals to upland grazing zones for improved welfare.

Figure 7 summarizes the Chopans' seasonal transhumance, aligning changes in elevation with key temporal stages: entrustment, movement through intervening pastures, highland grazing, return, and winter stall feeding. The vertical scale of this migration spans from village elevations (~1750–1940 m) to alpine zones above 3,000 m.

During migration, Chopan herders make temporary halts in forested areas along traditional routes, departing early in the morning to avoid road congestion. These stopovers typically last three to 4 days and depend on vegetation availability and highland accessibility. Grazing patterns are carefully adjusted to the phenological stages of pasture vegetation, with earlier growth observed in transitional altitudinal zones. This reflects the Chopans' nuanced, experience-based knowledge of landscape and climate dynamics.

In the Trajan pasture, the Chopans establish two types of stone-and-tarpaulin structures (temporary shelters): one used for sleeping and another as a kitchen. Herding is conducted in a rotating pattern, with one individual remaining at camp while others guide the flock to different sectors of the pasture daily. This pattern, responsive to rainfall and sunlight, is designed to optimize forage intake and support vegetation regeneration.

Figure 8 illustrates the intra-pasture grazing pattern in Trajan. It includes rotational grazing locations over several days (e.g., Boneh Trajan, Dam Dam, Bod Nar, Gagar Pather, Hapath Hoie), night camps, glacial water sources, and infrastructure such as temporary shelters and military roads. This map-based representation highlights the spatial organization of daily pastoral activities and the importance of adaptive movement within a constrained alpine ecosystem. The daily grazing pattern is adapted to environmental uncertainty, particularly the sequence of rainfall followed by sunlight. Chopans observe that fresh and nutritious grass emerges rapidly after rain when followed by sun, and they adjust grazing accordingly to maximize sheep health and forage quality.

Traditional ecological knowledge is central to Chopan pastoralism and is evident in their ability to anticipate weather changes, select appropriate grazing sites, treat livestock ailments

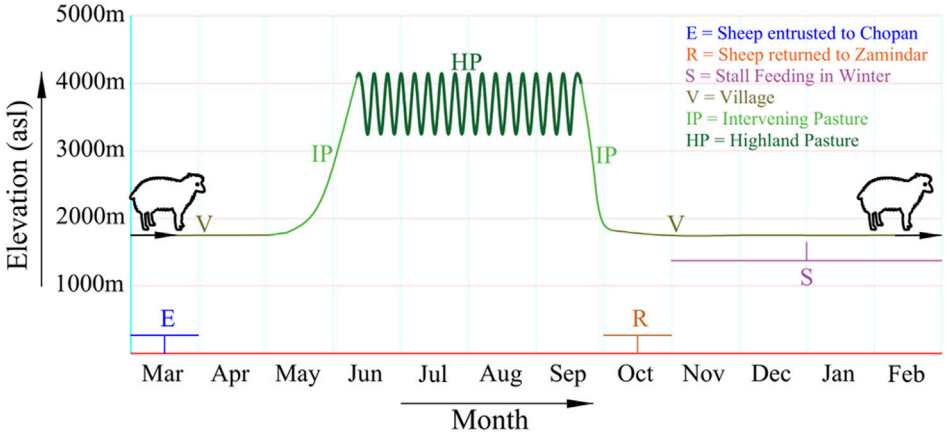

FIGURE 7
Seasonal transhumance trajectory of Chopan pastoralists in Baramulla District, showing the vertical movement of sheep from lowland villages to highland pastures (Trajan) and back. The figure aligns the migration cycle with monthly intervals and elevation changes, highlighting key stages: sheep entrustment to Chopans, temporary stops in intervening pastures, high-altitude summer grazing, and return to zamindars for winter stall feeding. Based on fieldwork data and prepared by authors using Google Earth, topographic-map.com, and Autodesk AutoCAD 2023 (2025).

using medicinal plants, and manage pasture sustainability. Grazing areas are systematically rotated to ensure optimal fodder quality and availability for the sheep. While participants emphasized that the availability of grasses is generally sufficient and that overuse is unlikely, field observations indicated that their daily grazing patterns—shaped by experiential knowledge and environmental responsiveness—naturally prevent overgrazing and contribute to ecological balance.

Environmental impacts and benefits

The findings indicate that Chopan pastoralism provides several important environmental benefits. This practice converts otherwise unused alpine grassland vegetation into protein, thereby preventing biomass loss in areas where alternative land uses are not feasible. Pastures such as Trajan, situated along the border between Pakistan-administered and Indian-administered Kashmir, are ecologically sensitive zones located above the treeline. These landscapes are unsuitable for agriculture or plantation due to their rocky terrain, steep gradients, and frequent cloud cover and rainfall. One Chopan remarked that "these pastures were created for livestock; if they do not graze here, the land will become like the neglected wetlands of Kashmir." Such comments reflect an embedded ecological ethic among herders.

The continued presence of pastoralists also mediates wildlife-human interactions. Predators—primarily wild animals—are known to take one to two sheep per week. Without pastoral presence in these zones, such animals may approach more densely populated areas, including the tourist destination of Gulmarg. As Hussain (2019) notes in his ethnographic study of snow leopard conservation in the Western Himalaya, such interactions reveal the limitations of dichotomous framings that separate the wild from the domestic or the ecological from the cultural. Snow leopards, for example, frequently rely on domestic livestock for sustenance, particularly in areas where human populations and pastoral herding are present, suggesting that the survival of such predators is entangled with pastoral livelihoods rather than threatened by them. This perspective complicates dominant conservation discourses that often portray herders as ecologically detrimental. In the case of the Chopans, managing predation involves not only physical practices of protection but also embodied knowledge of terrain, seasonal patterns, and animal behavior—forms of environmental engagement that are largely overlooked in formal conservation policy but are critical to sustaining coexistence in these frontier landscapes.

In lowland areas, Chopans provide ecosystem services to farmers and orchard owners by grazing sheep on grasses that harbor pests, reducing rat populations near apple trees. Sheep manure contributes to soil fertility in both highland pastures and village agricultural systems. Because herders guide animals across wide areas, manure is evenly distributed, eliminating the need for manual labor for fertilization.

Contrary to common assumptions about overgrazing, Chopans reported sufficient fodder availability in the Trajan pasture, attributed to the rapid regrowth of grasses due to frequent rainfall and their rotational grazing practices that help preserve vegetation cover. Based on the proxy yield from the ecologically similar Diskel pasture and applying a standard 50% utilization rate, the estimated usable forage in Trajan is 1,940 kg per hectare.

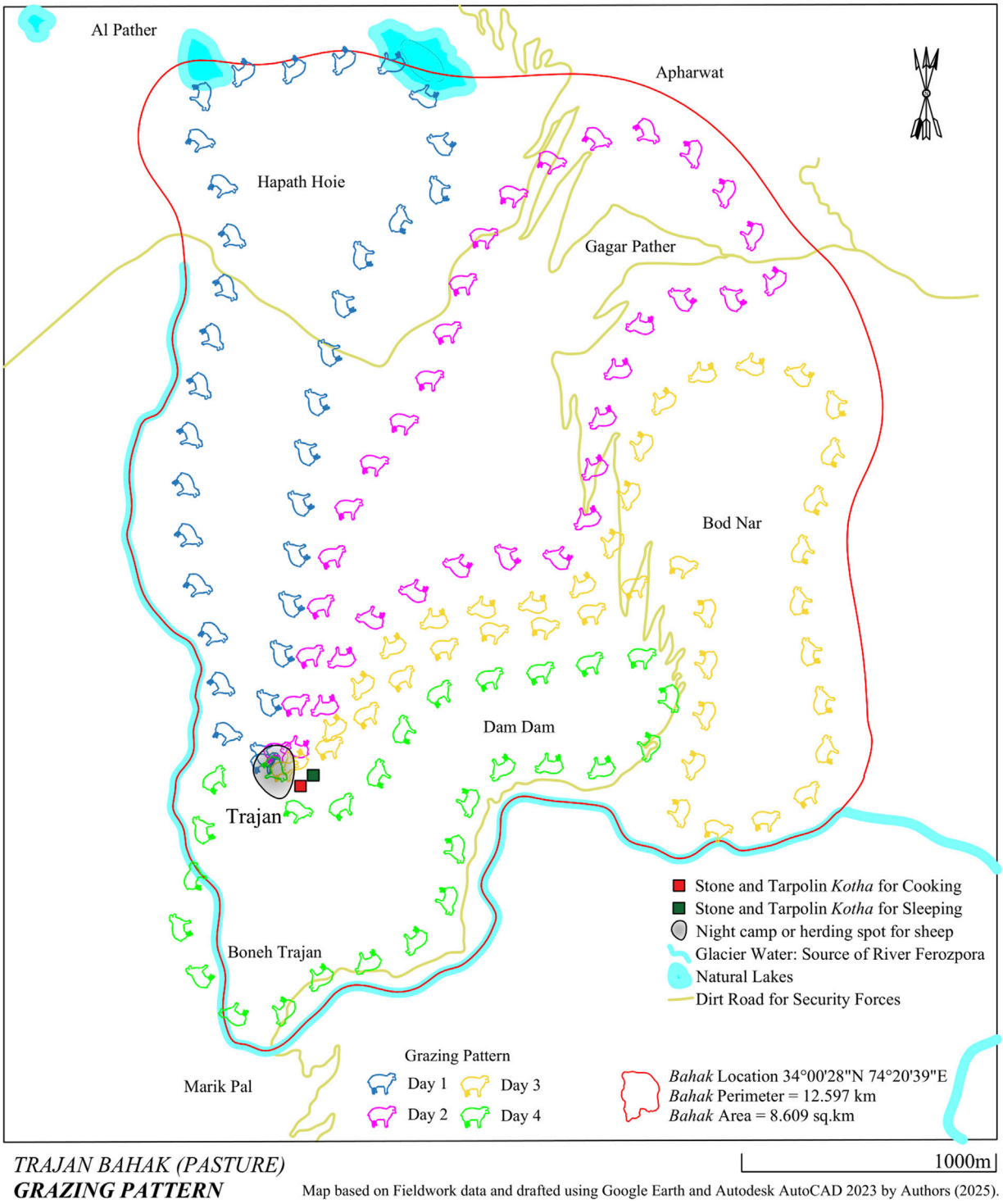

FIGURE 8
Intra-pasture grazing pattern of Chopan pastoralists in Trajan Bahak, showing rotational movement across key zones (e.g., Boneh Trajan, Dam Dam, Bod Nar, Gagar Pather, Hapath Hoie) over a 4-day cycle. The map also indicates stone-and-tarpaulin shelters, night camps, natural water sources, and dirt roads of security forces. Based on fieldwork data and drafted by authors using Google Earth and Autodesk AutoCAD 2023 (2025).

TABLE 1 Estimated grazing capacity of Trajan pasture based on forage yield and stocking data. Values are based on a 50% forage utilization rate and a seasonal grazing period of 50 days.

Indicator	Value	Source/Notes
Pasture area	860.9 ha	Mapping
Total number of sheep	2,650	Field data
Grazing season	50 days	Based on grass regrowth cycle
Forage requirement	65 kg/AU	Holechek (1988); Saleem et al. (2024a)
Dry forage yield (Diskel proxy)	3.88 t/ha	Saleem et al. (2024a)
Usable Forage (50% utilization)	1,950 kg/ha	Rangeland management standard
Carrying Capacity (based on Diskel yield)	29.85 AU/ha	Derived from above
Observed Stocking Rate	3.08 AU/ha	2,650 sheep over 860.9 ha
Carrying Rate (Diskel-based)	10.32%	(Stocking rate/Carrying capacity) × 100
Dry forage yield (regional avg.)	5.16 t/ha	Saleem et al. (2024b)
Adjusted carrying rate (regional avg.)	7.75%	Based on higher forage availability

Note: AU, Animal Unit (1 AU = 1 sheep of ~52 kg body weight). Carrying rate represents the percentage of ecological carrying capacity currently used.

Given a seasonal forage requirement of 65 kg per animal unit (AU), the carrying capacity of the Trajan pasture is calculated at 29.85 AU/ha. With 2,650 sheep grazing over an area of 860.9 ha, the observed stocking rate is 3.08 AU/ha, resulting in a carrying rate of just 10.32%. If the region-wide average yield of 5.16 t/ha (Saleem et al. 2024b) were used instead, the carrying rate would be even lower—approximately 7.75%. This suggests that only a small fraction of the pasture's productive potential is currently being utilized which is well within sustainable limits. Table 1 summarizes the key indicators used in assessing the grazing potential of the Trajan pasture.

Food security and economic importance

Livestock rearing has long been a central component of rural life in Jammu and Kashmir, historically embedded in agrarian livelihoods and local food systems (Lawrence 1895). Today, livestock continues to play a critical role in the region's rural economy and food security. Government data indicate that livestock remains the primary source of meat and milk protein, with mutton occupying a particularly central place in Kashmiri cuisine. As per the 20th Livestock Census, the livestock and poultry populations of Jammu and Kashmir and Ladakh stand at 8.32 million and 7.37 million, respectively (Hamdani et al. 2022). The region also exhibits one of the highest livestock densities in the country, with 882 animals per 1,000 people, compared to the national average of 457 (Kumar, Kher, and Dwivedi 2012), underscoring the continued socio-economic importance of pastoral and agro-pastoral livelihoods.

Census data from 2011 reveal that approximately 73% of the population resides in rural areas and remains directly or indirectly involved in agriculture and allied sectors, including livestock rearing as main occupation (Livestock Breeding Policy 2019). Despite this reliance, local meat production fails to meet demand. Of the annual 310 lakh kilograms of mutton required, only 135 lakh kilograms are produced within the region, necessitating the import of approximately 175 lakh kilograms to fill the deficit (see Figure 9). While Jammu and Kashmir historically experienced growth in livestock populations—especially sheep—outpacing human population growth in earlier decades, more recent years have shown fluctuations and even declines in sheep numbers (see Figure 10).

Land use changes further compound concerns over local food production and pastoral sustainability. Between 1990 and 2017, the total agricultural area in Jammu and Kashmir declined by 278 km^2 (a 5% decrease), while built-up areas increased from 133 km^2 to 313 km^2, marking a 3% gain (Rasool et al. 2021). These shifts not only impact food security but also alter the ecological and social landscapes upon which traditional livestock-based livelihoods have long depended.

Challenges and policy impacts

Chopan pastoralists face a range of structural and environmental challenges that directly impact their livelihoods. A major concern is the loss of traditional grazing areas, particularly village commons (*Kahcharai*), which have been increasingly appropriated by powerful individuals or converted for infrastructure development. This has significantly reduced available grazing spaces prior to seasonal migration to highland pastures. Additionally, government-imposed forest restrictions, including fencing,

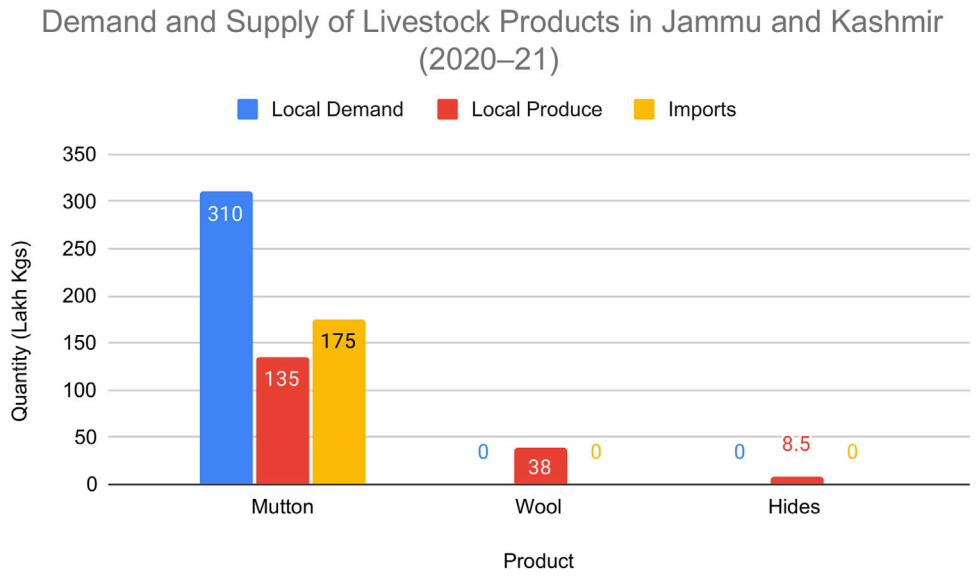

FIGURE 9
Demand and supply of livestock products in Jammu and Kashmir (2020–21). Source: Developed by authors (2025) based on data from Sheep Husbandry Department, Kashmir (https://jksheephusbandrykashmir.nic.in).

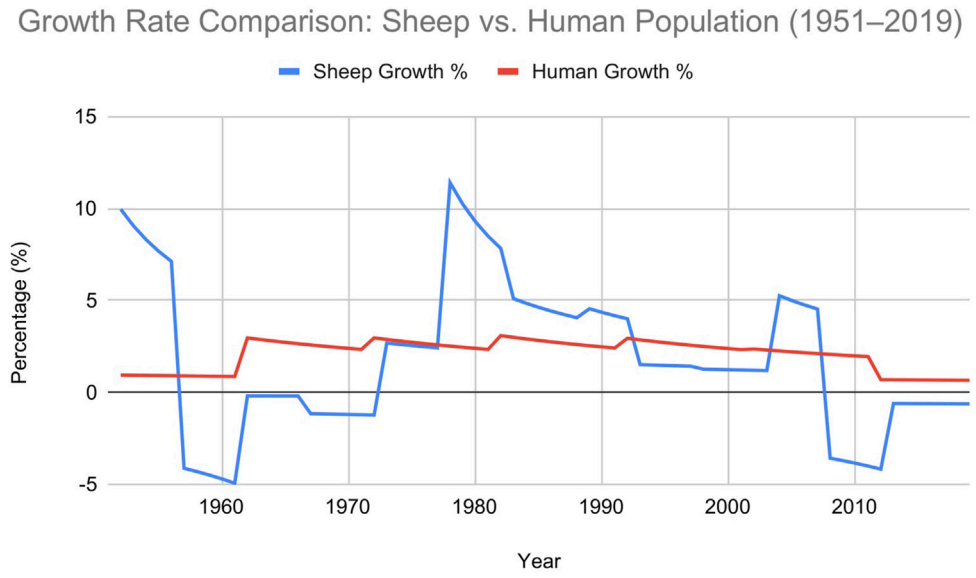

FIGURE 10
Growth rate comparison of sheep and human populations in Jammu and Kashmir (1951–2019). Developed by authors (2025) based on data from Ministry of Finance, Government of India (2022); Digest of Statistics (2019–20, 2021–22), Department of Planning, Government of Jammu and Kashmir; 20th and 18th Livestock Census (data.gov.in); and Department of Animal Husbandry, J&K (https://www.jkanimalhusbandry.net).

have limited access to traditional migration routes and resting points in intervening pastures, disrupting long-established patterns of mobility. This is seen as a serious issue by Chopan pastoralists.

Pastoralists are also exposed to risks from wild animals and feral dogs, which endanger both livestock and herders, particularly during transit and in remote grazing areas. In the Trajan pasture, the pastoralists' sheep are under threat by the

dogs that they believe have been imported to the area by the Indian Security Forces.

Compounding these challenges is the lack of essential services in highland regions. There is no access to medical care for either herders or their livestock, and limited communication infrastructure further isolates these communities. There is no electric facility, no mobile networks and no road connectivity. Despite their critical role in sustaining the livestock economy, Chopans remain economically marginalized, with minimal institutional support or formal recognition. Policy frameworks have largely neglected pastoralism, focusing instead on agricultural intensification and intensive pastoralism. For example, the Jammu and Kashmir State Action Plan on Climate Change—drafted in 2011 but never implemented—misrepresents pastoral grazing as inherently destructive to forests and pastures, a view that is increasingly contradicted by contemporary scientific research emphasizing the ecological value of well-managed pastoral systems.

When this policy neglect was discussed with Chopan herders during fieldwork, they responded with resignation and irony, asking, "Have any of those policymakers ever visited these pastures? Did they ever think about us too?" Their rhetorical questions underscore the disconnect between policy narratives and lived realities on the ground, highlighting the urgent need for more inclusive, context-sensitive governance in pastoral regions.

Discussion

Rethinking pastoral impacts on highland ecosystems

The findings of this study challenge dominant narratives that depict pastoralism as inherently damaging to highland ecosystems. Despite supporting approximately 2,650 sheep, the Trajan pasture shows no visible signs of ecological degradation—an assessment confirmed both by the lived experiences of Chopan pastoralists and direct field observations. When compared with the ecologically similar Diskel pasture (33°49′55″N 74°33′45″E), Trajan appears in notably better ecological condition. This can be attributed, in part, to its remoteness: situated at 34°00′28″N 74°20′39″E near the Line of Control, the pasture remains inaccessible to tourism, agricultural development, and infrastructural encroachment.

The estimated carrying rate of just 10.32% illustrates that grazing pressure in Trajan remains well within sustainable limits. Pastoralists are thus utilizing land that would otherwise remain ecologically unproductive, demonstrating a low-impact form of land use that contributes to regional food systems. These findings are consistent with recent research by Saleem et al. (2024b) and Mugloo et al. (2023), which report high levels of aboveground biomass in Kashmir's alpine pastures, supported by favorable soil conditions, sufficient precipitation, and sustainable grazing practices.

The microclimatic features of highland pastures—frequent rainfall, cool temperatures, and variable sunlight—also promote rapid regrowth of herbaceous vegetation. Furthermore, temperate environments are known to store significant amounts of soil organic carbon due to slower decomposition rates in colder climates (Ding et al. 2017), suggesting that well-managed pastures such as Trajan may contribute to carbon sequestration and broader climate mitigation goals.

Importantly, these alpine pastures lie above the tree line, rendering them unsuitable for forestry or conventional agriculture. Attempts by the Forest Department to cultivate tree species in similar zones have repeatedly failed. In addition, the militarized status of the border region precludes tourism and commercial expansion. In this context, pastoralism emerges not only as a viable land use but arguably the most sustainable and ecologically compatible form of human activity in these fragile landscapes.

These findings align with broader ecological research suggesting that pastoralism can play a potentially important role in shaping grassland ecosystems. Managed grazing has been shown to influence plant species composition, promote habitat diversity, and enhance ecosystem functioning (Scasta et al. 2016). In the case of Trajan, Chopan pastoralists suggest the value of traditional ecological knowledge in sustaining landscapes that are otherwise marginalized in land use policy and development planning.

Pastoralism and climate change mitigation

This study reinforces the growing call to differentiate between intensive and extensive livestock systems in climate policy and emissions accounting. As García-Dory, Houzer, and Scoones (2022) argue, dominant climate discourses tend to homogenize all livestock systems as environmentally harmful, often ignoring the relatively low-impact nature and socio-ecological value of pastoralist systems. Such generalizations obscure critical distinctions in land use, energy input, and ecosystem interaction.

Most greenhouse gas assessments are based on data from industrial livestock systems, where animals are confined, feed is externally sourced, and emissions are concentrated. These models often overlook the complexities of carbon and nitrogen cycles inherent in extensive grazing systems, including natural carbon sequestration through pasture regrowth and soil enrichment. In the context of northern India, Panwar et al. (2022) report high carbon sequestration potential in pastoral landscapes, including those in Jammu and Kashmir, due to substantial aboveground biomass productivity.

Furthermore, many commonly proposed methane mitigation strategies (FAO 2023)—such as methane inhibitors,

dietary additives, electron sinks, and anaerobic digesters—are designed for controlled feedlot environments and are impractical or irrelevant in open, extensive pastoral systems (Mukherji et al. 2023). Applying such strategies without adaptation risks further marginalizing pastoralist communities and distorting emissions estimates.

These findings underscore the importance of involving pastoralists in the development of climate mitigation strategies that are appropriate to their ecological and cultural contexts. Recognizing the environmental services embedded in pastoralist practices—such as nutrient cycling, soil fertility maintenance, and sustainable land use—is critical for crafting equitable and effective climate policies. Extensive livestock systems, when rooted in traditional ecological knowledge and adaptive mobility, can form part of the solution to climate change rather than being cast solely as a problem.

Food security and socioeconomic implications

Any policy that restricts pastoral practices in Jammu and Kashmir is likely to have significant implications for regional food security. The region already imports approximately 56% of its annual mutton requirement, and agricultural land is steadily declining due to urban expansion and land-use change. Further constraints on livestock production—particularly extensive pastoralism—would exacerbate the existing protein deficit, compromising both dietary diversity and nutritional adequacy.

The socioeconomic impacts of such restrictions would be particularly severe for Chopan pastoralists, who already occupy a marginalized position within state development frameworks and receive minimal institutional support. Following the abrogation of Article 370 and the reorganisation of Jammu and Kashmir as a Union Territory, the Forest Rights Act (FRA) of 2006 was formally extended to the region. While this was initially seen as a progressive step (Ashiq 2021), the absence of operational mechanisms—such as Forest Rights Committees, Sub-Divisional Level Committees, and effective claim verification—has rendered the Act largely non-functional in practice. Chopans encountered during fieldwork were unaware of their rights under the FRA, despite fulfilling the criteria of "other traditional forest dwellers" under Section 2(o), and engaging in transhumant grazing covered under Section 3(1)(d) of the Indian FRA 2006. This exclusion is rooted in institutional neglect, lack of Scheduled Tribe status, and state imaginaries that continue to privilege sedentary agriculture over mobile livelihoods. In several areas, the Forest Department has demolished seasonal mud-and-log huts (*kothas*) used by pastoralists during their summer migrations. As one pastoralist remarked, "We have not occupied these lands . . . we live there only for 6 months in the summer, so why is this being done now?" (Sharma 2021)—highlighting the disjuncture between legal definitions of occupation and pastoralist rhythms of land use. In 2021, although the Lieutenant Governor distributed FRA certificates to Gujjar, Bakarwal, Gaddi, and Sippi communities, the Chopans—despite qualifying under the Act—were neither invited nor acknowledged (Bhat 2021). Their prolonged exclusion from ST status can be attributed not only to the absence of political will, but also to their scattered settlement pattern, continued mobility, and weak collective organisation. Unlike Gujjars and Bakarwals, who benefit from cohesive community networks and political representation, the Chopans remain largely outside formal advocacy spaces and welfare schemes. This structural marginalisation within both policy and social hierarchies contributes to their limited engagement with state institutions, leaving them especially vulnerable to eviction and exclusion from forest governance frameworks.

This exclusion has material consequences. In violation of Section 4(5) of the Indian FRA, eviction notices have been issued to Chopans and other pastoralists prior to the resolution of land claims (Bhat 2023). Many are unable to furnish the required documentation despite long-standing pastoral use, and some now express willingness to abandon mobility and settle permanently (Sharma 2021). Of over 46,000 claims filed under the FRA, more than 39,000 have been rejected as of March 2025—primarily at the Gram sabha level—often due to procedural ambiguities and lack of institutional support. Approved land titles have been overwhelmingly concentrated in the Jammu region, mainly among Scheduled Tribe beneficiaries, while Kashmir has seen minimal recognition, with no titles issued in districts such as Baramulla or Srinagar (Deccan Herald 2025). An RTI inquiry found that none of the 81 approved community claims in districts like Kupwara and Budgam included Chopans or Other Traditional Forest Dwellers (OTFD) groups, highlighting their continued exclusion from FRA implementation (Bhat 2022). These disparities reflect deeper epistemological and bureaucratic biases that fail to acknowledge mobility, seasonality, and customary land use as legitimate forms of forest dependence. As Singh et al. (2022) show in the context of Khangchendzonga National Park, such frameworks disproportionately affect economically vulnerable herders, while better-resourced actors often navigate these constraints through informal or political channels. The Chopans' experience illustrates how the extension of legal protections, in the absence of structural reform, can reproduce entrenched patterns of spatial and political marginalisation.

At the same time, global policy shifts toward plant-based and alternative proteins raise questions about equity, cultural appropriateness, and accessibility. While these alternatives may serve as sustainable options in some contexts, e.g., in certain parts of the global north, their affordability and availability remain limited in regions like Jammu and Kashmir, where animal-source foods continue to play a critical role in both nutrition and cultural identity (Beal et al.

2017; Ryckman et al. 2021). Meat, in particular, holds significant cultural value, featuring prominently in traditional Kashmiri cuisine—most notably in *Wazwan*, a ceremonial multi-course meal central to social and religious celebrations in Kashmir.

Despite the ecological sustainability of pastoralism in highland regions, local livestock production does not meet existing demand. On average, approximately 1.47 million heads of small ruminants are imported annually from Rajasthan to supply the mutton market in Jammu and Kashmir (Shah et al. 2020). With population growth and dietary preferences showing no signs of shifting away from meat consumption, this supply-demand gap is expected to widen in the future. In this context, supporting pastoralism is not only a matter of livelihood preservation but also of nutritional sovereignty and cultural continuity.

Traditional ecological knowledge and policy development

This study underscores the importance of traditional ecological knowledge (TEK) in shaping sustainable practices within pastoral landscapes. Chopan pastoralists possess a nuanced understanding of microclimatic variability, vegetation cycles, and animal movement, which enables them to manage alpine grazing systems in ways that optimize forage use while minimizing ecological degradation. What may appear to external observers as marginal or fragile land is, in practice, adaptively managed through longstanding experiential knowledge. These findings align with broader research that highlights the value of integrating TEK with scientific monitoring. Reid-Shaw et al. (2021), for instance, suggested that combining Mongolian herders' knowledge with ecological data significantly enhanced the understanding of environmental trends across ecological zones. Similarly, Reid et al. (2004) emphasize that climate mitigation strategies are most effective when grounded in traditional pastoral institutions, particularly when they offer co-benefits such as food security, social cohesion, and environmentally appropriate land use.

Despite this, current policy approaches in Jammu and Kashmir—like in many pastoral contexts—tend to privilege externally generated data and global narratives over local insight. The Jammu and Kashmir State Action Plan on Climate Change exemplifies this disjuncture; it characterizes pastoral grazing as uniformly destructive, despite ethnographic and ecological evidence to the contrary, including findings presented in this article. The Livestock Breeding Policy (2019) in Jammu and Kashmir also supports primarily unemployed youth establishing intensive livestock units, overlooking the foundational role that extensive pastoralism plays in sustaining such systems. As shown in this study, even intensive livestock production in the region remains ecologically and economically dependent on seasonal access to highland pastures managed by Chopan pastoralists, whose contributions remain unrecognized in policy frameworks. Such policies risk marginalizing pastoralists further by failing to recognize the ecological services embedded in their adaptive practices.

As Jasanoff (2004) argues, meaningful and equitable environmental governance requires the co-production of knowledge, in which scientific and local epistemologies are brought into dialogue. For such co-production to occur, pastoralists must be included not merely as stakeholders but as co-designers of policy frameworks. A bottom-up, pilot-based approach—grounded in local institutions, knowledge systems, and needs—offers a more promising pathway toward context-sensitive and effective climate adaptation strategies. Recognizing and institutionalizing TEK is therefore essential not only for ecological stewardship but also for the socio-political inclusion of pastoralist communities in future decision-making processes.

Conclusion

This study suggests that transhumant pastoralism, as practiced by Chopan communities in the highland pastures of Jammu and Kashmir, is not a relic of the past but a dynamic, sustainable adaptation to variable and ecologically marginal environments. Far from contributing to degradation, Chopan pastoralism supports multiple environmental and social functions: converting underutilized biomass into high-value protein, maintaining soil fertility through natural manure distribution both in highlands and lowlands, managing human-wildlife interactions, and contributing to regional food security in a context of declining agricultural land and growing protein deficits.

Our ethnographic and ecological findings challenge prevailing policy narratives and climate discourses that portray all livestock systems as environmentally harmful. The case of the Trajan pasture—where the observed carrying rate is only 10.32%—suggests that Chopan grazing practices are ecologically balanced and well within sustainable limits. These landscapes, located above the treeline and unsuitable for agriculture or plantation, are managed by herders who rely on deep environmental knowledge, rotational grazing, and microclimatic sensitivity. The Chopans' presence not only sustains livelihoods but also actively shapes the resilience of alpine ecosystems that would otherwise remain ecologically underutilized.

This research underscores the importance of distinguishing between intensive, industrial livestock systems and extensive, low-emission pastoral practices. Applying uniform emission metrics and mitigation strategies—such as methane inhibitors or controlled feed systems—risks mischaracterizing the climate impact of pastoralism and marginalizing those whose practices already align with sustainable land use. The climate benefits of

grassland-based systems, including carbon sequestration in soils and reduced dependence on fossil-fuel-based inputs, remain underexplored and undervalued.

Despite these contributions, pastoralists remain structurally excluded from policy processes. Institutional frameworks—such as the Jammu and Kashmir State Action Plan on Climate Change and the post-370 implementation of the Forest Rights Act—have overlooked or undermined pastoral livelihoods. Policies designed without pastoralist input often misrepresent their role in ecosystem dynamics and restrict access to commons and migration corridors. As one Chopan poignantly asked, "*Did any of the policymakers ever visit these pastures?*" This reflects not only exclusion but a missed opportunity to ground climate and development policy in lived ecological knowledge.

The findings of this study also align with recent global frameworks such as the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 Synthesis Report, which emphasises the value of integrating diverse knowledge systems—scientific, Indigenous, and local—into climate adaptation strategies (IPCC 2023). The adaptive practices of Chopan pastoralists demonstrate the kind of situated environmental knowledge that is often undervalued in formal policy. As the AR6 highlights, climate justice entails not only *distributive justice* (the fair sharing of risks and benefits), but also *procedural justice* (meaningful participation in governance), and *recognition* (respect for different ways of knowing and being). Supporting mobile pastoralists through inclusive governance, protection of migratory corridors, and legal recognition of traditional use rights is not only ecologically sound but also essential to just and equitable climate adaptation.

To address these gaps, we recommend the following multilevel policy actions.

(A) At the national level (Ministry of Tribal Affairs, MoEFCC):
   I. Legally differentiate between intensive and extensive livestock systems in climate assessments and livestock-related policies.
   II. Ensure the effective implementation of the Forest Rights Act for transhumant communities, including recognition of OTFD status for Chopans and protection from eviction.
   III. Designate the Tribal Affairs Department—not the Forest Department—as the nodal agency for FRA implementation in Jammu and Kashmir to better align institutional priorities with tribal rights.

(B) At the regional level (Jammu and Kashmir administration):
   IV. Integrate traditional ecological knowledge into rangeland monitoring and adaptation strategies specific to high-altitude ecosystems.
   V. Secure pastoral mobility and legal access to alpine and subalpine grazing lands through inclusive commons governance and tenure reforms.
   VI. Provide context-sensitive livestock development programs that reflect the ecological, cultural, and migratory specificity of pastoral systems in Kashmir.

(C) At the global level (FAO, IPCC, UNFCCC, development donors):
   VII. Incorporate the contributions of mobile pastoralists into climate adaptation and biodiversity frameworks, particularly in relation to low-emission protein production, ecosystem stewardship, and resilience in marginal environments.
   VIII. Establish mechanisms for meaningful pastoralist participation in climate governance, including local representation in planning, implementation, and monitoring processes.

Ultimately, this case study contributes to a growing body of research suggesting that pastoralism in high-altitude, marginal environments can offer sustainable livelihoods and serve as a model for resilient, low-impact land use under conditions of climate uncertainty. However, we emphasise that these findings emerge from a single, context-specific study of Chopan pastoralists in the Trajan pasture of Baramulla District, Jammu and Kashmir. While the ecological and institutional insights presented here are valuable, they are not intended to represent the diversity of pastoral systems across the broader Himalayan region. As such, the policy recommendations outlined in this study should be viewed as entry points for more inclusive, differentiated, and locally informed dialogue. Recognising the heterogeneity of pastoral communities and the context-specific nature of their adaptive strategies is essential to crafting just and ecologically appropriate climate and land-use policies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because Ethical approval was not required under the policies of the authors' institutions, as the study did not involve biomedical interventions, sensitive personal data, or research with minors or legally vulnerable individuals. The research complied with standard ethical protocols in anthropology, including voluntary participation, confidentiality, and cultural sensitivity. In addition, prior permission was obtained from the relevant authorities in Jammu and Kashmir to conduct research in the high-altitude Trajan pasture, a sensitive border area near

the Line of Control. These permissions were essential for access to the field site and were secured before the commencement of fieldwork. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IB was responsible for the methodology, conducted the fieldwork, reviewed relevant literature, and collected secondary data. IB also carried out the results and analysis, and prepared the initial draft of the manuscript. IB, RS, and MR jointly contributed to the review, editing, and final approval of the manuscript for submission. All authors reviewed the results and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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