

Research

Plantations and pastoralists: afforestation activities make pastoralists in the Indian Himalaya vulnerable

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ABSTRACT. Global policies to mitigate climate change and protect forests are increasingly incentivizing the large-scale planting of trees. Yet tree planting poses a potential threat to the well-being of migratory pastoralists who depend on fodder across landscapes. With this research we seek to understand the impact of decades of afforestation activities in Himachal Pradesh, India, on the livelihoods of Gaddi pastoralists who have herded sheep and goats in the Himalayas for generations. Based on interviews with Gaddi herders, community leaders, and government officials, and case studies in three villages with large Gaddi populations in Kangra district, we find that plantations increase vulnerability. We show that plantations have decreased the availability of fodder, contributed to increased incidence of invasive species, disrupted migratory routes, and changed access to land. We develop a generalizable integrated vulnerability framework that focuses on pastoral livelihoods, and helps make a distinction between the vulnerability of livelihood activities and the vulnerability of individual people. Our framework anchors the causal pathway from plantation activity to livelihood vulnerability and the push toward more secure, but nonpastoral livelihoods. Plantation-driven challenges add to pre-existing stressors and accelerate declines in the number of pastoral households and size of migratory herds. However, many Gaddi households remain prosperous because they are able to diversify into alternative livelihoods. We underline the fact that the ability to adapt to alternative livelihoods and income streams differentiates vulnerable Gaddi herders from those who are not. In addition to increasing forest cover, plantations have an opportunity to serve a larger purpose of increasing resilience of vulnerable livelihoods; but they must be designed differently than they have been in the past in order to achieve this goal. They present an easier solution to sustain pastoralism compared to other important, but recalcitrant drivers of livelihood change.

Key Words: *access; afforestation; institutions; resilience; transhumance*

INTRODUCTION

Pastoralists are at risk from an increasing array of social and biophysical stressors (Sayre et al. 2013, Reid et al. 2014, Robinson 2019, Unks et al. 2019). One potential threat that has not been widely studied is afforestation activities that displace grazing lands (Joshi et al. 2018, Bond et al. 2019). We develop a generalizable integrated vulnerability framework and apply it to three cases of Gaddi pastoralists in the winter grazing areas of the western Himalayas in India, a landscape that has been heavily impacted by tree plantation activity for at least the last five decades and provides a view of what many places in the world may look like in a future of large-scale forest restoration. We make the distinction between the vulnerability of livelihood activities and the vulnerability of individual people, highlighting the cultural, political, and economic conditions that permit individual Gaddi herders to adapt to the increased vulnerability of pastoral livelihoods, which is the result of a constellation of threats, including heavy afforestation. The framework anchors the causal pathway from plantation activity to livelihood vulnerability in four land uses that change species composition, force route changes, and reshape access mechanisms that together increase livelihood vulnerability and push pastoralists toward nonpastoral livelihoods that sometimes are more secure.

FRAMEWORK

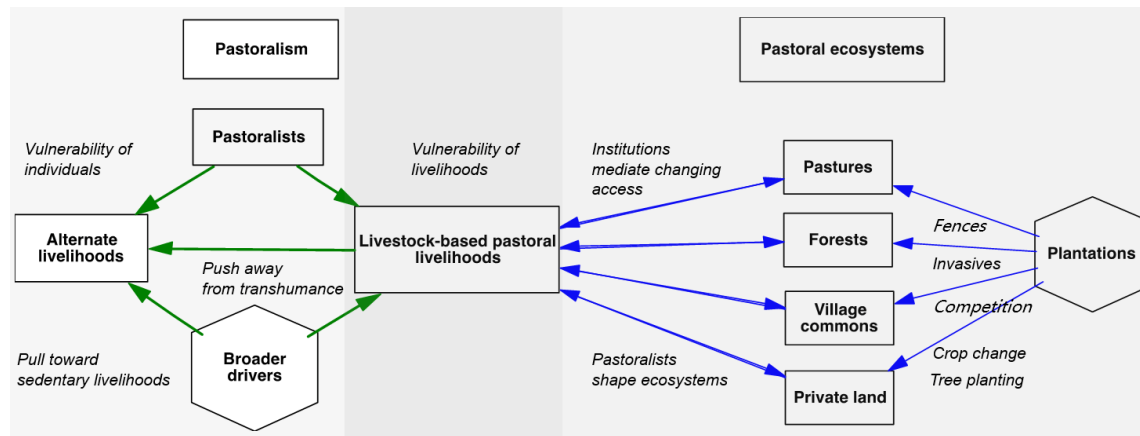
Our framework (see Fig. 1) is innovative in integrating the property rights and land uses that pastoralists have in pastoral ecosystems (right-hand side of figure), with the complex livelihood choices of pastoralists (left-hand side of figure). Past

literature on livelihood change among pastoralists in India, and Gaddis in particular, has focused on how changing property rights have negatively influenced pastoral livelihoods (Chakravarty-Kaul 1998, Saberwal 1999, Axelby 2007). Although this is important as a driver of change, it misses two important dynamics that our framework highlights. First, beyond changes in de facto and de jure property rights, pastoralists are also influenced by long-term changes in land cover driven by government afforestation plantations, which we focus on in this paper. Second, although pastoral livelihoods are undoubtedly under threat, the well-being of pastoralists is influenced not only by their pastoral livelihoods, but also by their ability to shift to alternative livelihoods, an ability that explains the continuing prosperity of many Gaddi households in our study area in the face of challenging conditions for pastoral work.

Our framework places livestock-based pastoral livelihoods at the center. These livelihoods are influenced by changing dynamics and institutional relationships with pastoral ecosystems: pastures, forests, village common lands, and private land where herds graze (right-hand side of figure). The focus of past literature has been on how a variety of changes, the government control of forest land, the privatization of village commons, and the intensification of agriculture on private lands, have decreased the availability of grazing from these ecosystems (Saberwal 1999, Axelby 2007, Wagner 2013; Chakravarty-Kaul 1996, *unpublished manuscript*). Plantations also decrease the availability of fodder because they rely on fencing areas of forest, pasture, or common land, replace palatable grass and brush with unpalatable trees, and are reported to facilitate the spread of invasive ground covers. At the same

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Fig. 1. An integrated framework of pastoral vulnerability.



time, on the left-hand side of the figure we see that pastoralism itself is influenced by a broad array of other drivers that pull pastoralists away from herding and toward other livelihoods that are either less difficult, more culturally appropriate in a changing society, or more remunerative. Some of these broader drivers are identified as human land use change determined by growth of population, increasing consumption, capitalism, spread of markets, and commodification of ecosystem services; land fragmentation; shift in cropping patterns; and impacts of climate change (Robinson and Berkes 2010, Reid et al. 2014, Unks et al. 2019). The availability of alternative livelihoods is in turn influenced by trends in the regional economy. Together these factors interact resulting in an overall decline in livestock-based pastoral livelihoods in our study region, but continuing prosperity of many Gaddi households who are able to diversify into alternative livelihoods.

Vulnerability analysis is broadly based on two approaches: the risk-hazard and social constructivist (Füssel and Klein 2006, O'Brien et al. 2007, Ribot 2014). Although the former examines the linear relationship between a specific biophysical risk and multiple outcomes of the risk, the latter traces the multiple underlying social and political-economic causes of a single outcome of vulnerability. The primary limitation of both approaches is that they fail to grapple with the underlying social structural causes of vulnerability together with biophysical risks, both of which together bring households to thresholds of extreme vulnerability (Ribot 2014, Ramprasad 2019), the condition that renders any change in resource critical. In response to this limitation, recent integrative models aspire to link biophysical and social factors for a more complete explanation of why a set of people are at risk from particular social and biophysical damages (Ribot 2014, Ramprasad 2019). We follow this new integrative path by examining how afforestation enhances pre-existing social and biophysical risks on pastoral livelihoods.

We go a step further and distinguish between the vulnerability of people from the vulnerability of their livelihood activities. Making this distinction helps examine the environmental consequences of livelihood change because it recognizes the multiple income streams from various activities people use to earn a living, and the different combinations of activities people use to manage risk

or take advantage of alternate opportunities. This distinction also helps clearly separate the risks to individuals from the risks to their livelihood activities. The risks to people from changes in the livelihood activities depend on their ability to diversify income sources. This ability to shift between livelihoods depends in part on the assets, entitlements, and access at the disposal of households, which are well identified in existing vulnerability frameworks (Blaikie et al. 1994, Turner et al. 2003, Füssel and Klein 2006, Ribot 2014, Ramprasad 2019), but it also depends on the opportunities available (or not) in the broader social and political-economic context. Although most literature on the vulnerability of pastoral livelihoods has ignored this distinction, recent scholarship is beginning to pay attention to abilities and livelihood shifts in several pastoral systems worldwide (Galvin 2009, Reid et al. 2014, Mattalia et al. 2018, Unks et al. 2019). If pastoralists do not have any other livelihood options, a decline in pastoral livelihoods would mean increasing vulnerability of both pastoralists and pastoral livelihoods. However, research on livelihoods throughout the world demonstrates that most people earn income from multiple income streams and that the ability to diversify income sources is a key strategy to reduce vulnerability (Chambers and Conway 1992, Ellis 2000, Marschke and Berkes 2006). Among Gaddis, this ability is common. As a result, although pastoral livelihoods are declining, many pastoralists are thriving, primarily because they have diversified into nonpastoral livelihoods. Although we have no way to generalize to other pastoral populations, the literature on pastoralism is full of documented cases where pastoralists have other nonpastoral livelihood activities, such as trading, settled agriculture, skilled trades, and livelihoods based on education, government, and industry. The implications of this distinction are profound: if the only way to protect pastoral people is to maintain their pastoral livelihoods, that implies a very different set of policies than if pastoral people can also be protected by, for example, providing them greater political representation, investment capital to build up businesses, or education to allow them to actively participate in nonpastoral economy. On the other hand, recognizing both pastoral livelihoods and pastoral people as distinct values may mean a more mixed set of policy tools. Until now, policy has consistently mixed up the distinction between the two, with some supporting Gaddis by assisting their social mobility and

Table 1. Trees and grass tufts planted[†] in Himachal Pradesh, 1979–2015.

	1979–1988	1989–1998	1999–2008	2009–2015
Palatable	74814.43	84494.53	47133.69	22368.76
Nonpalatable	130103.19	133580.33	76422.57	39315.66
Other broad-leaved trees	61338.46	89297.56	70094.61	51395.99
Grass tufts	0	0	1607.45	2975.01
Total area planted (ha)	252.96	290.37	201.25	100.60
Total grass area planted (ha)	0	0	3.57	1.79
Total trees and grass tufts planted	266256.09	307372.42	195258.33	116055.42

[†] in '000s.

representation, while others have actively implemented policies of sedentarization and imposed grazing restrictions without listening to their livelihood demands, e.g., reviewing permits or providing real time climate information. We believe this distinction will be crucial in the future of livelihood scholarship because households may face greater difficulties making the shift because of lack of skills, discrimination, isolation from economic opportunity (Shah et al. 2018), or cultural or personal preferences for certain kinds of work.

Growing importance of afforestation in global and national policies and livelihood linkages

Although systematic reforestation and afforestation efforts have a long history, they have been given new impetus in the last decade by the widespread belief that reforestation and afforestation represent relatively low cost means toward mitigating climate change (Stern 2007, Holl and Brancalion 2020). This has taken shape through efforts to offset anthropogenic carbon emissions and decrease carbon sequestration loss from deforestation and forest degradation under the United Nations Framework Convention on Climate Change (Agrawal et al. 2011, Crouzeilles et al. 2016, The Bonn Challenge 2016). However, there is increasing global concern that some afforestation programs adversely affect the provision of a broad range of ecosystem services (Bremer and Farley 2010, Xu 2011, Menz et al. 2013, Balthazar et al. 2015, Veldman et al. 2015, Bond et al. 2019, Ojha et al. 2019), including some that rural populations depend on for their livelihoods (Gerber 2011, Andersson et al. 2016). However, there is little research that links afforestation to livelihoods (Le et al. 2012, Adams et al. 2016, Malkamäki et al. 2018) and some concern that afforestation may displace land covers that are useful to local livelihoods with ones that are oriented toward commercial extraction practiced by elites (Van Holt et al. 2016).

India has been a global leader in implementing afforestation programs (Fleischman 2014, Davis and Robbins 2018) and thus its experience provides a model for looking at the effects of widespread afforestation that is being encouraged in other countries. Between 1950 and 2005 central government statistics reported afforestation of an area equivalent to 10% of India's land area, or just less than half of its total forest cover (Ravindranath et al. 2007). Data we obtained in 2018 from the Himachal Pradesh Forest Department indicate a similarly widespread distribution of plantations along the migratory routes of the Gaddis (Table 1). Up until the 1990s, much plantation activity focused on replacing palatable broad-leaved tree species, e.g., *Quercus leucotricophora*, *Acacia catechu*, etc., and pastures with unpalatable native conifers, e.g., *Pinus roxburghii*, which

produce superior timber and resin. More recent plantation programs in the area have put greater emphasis on native broad-leaved species, which are also generally unpalatable, while still ignoring understory shrubs and herbs and native meadows. Further, India's afforestation programs are slated for expansion: in 2016 the central government proposed to allocate US\$6.2 billion to afforestation projects, with the goal of increasing the percent of India covered by forest from the current 21.34% to 33% (Balachandran 2016) as part of India's Intended Nationally Determined Contribution to reducing greenhouse gas emissions under the United Nations Framework Convention on Climate Change. This proposal, like similar proposals from previous governments (Ministry of Environment and Forests 2010), says little about the impacts of the proposed shift in land cover on rural livelihoods such as pastoralism.

Gaddis of the Himalaya

Gaddis are an agro-pastoral community, listed as a scheduled tribe by the Government of India, that trace their ancestry to Bharmour in Chamba district of Himachal Pradesh. Centuries ago, they settled in various regions of the Dhauladhar range in modern-day Kangra district (Fig. 2) with high concentrations around Palampur and Baijnath tehsils (a local term for a subdistrict government unit) and neighboring Chamba district. Pastoralism closely follows seasonal patterns of fodder availability with winters in the lower and middle altitude of Kangra and summers in higher altitudes of Kangra, Chamba, and Lahaul and Spiti valley (Fig. 3). Many of the 178,130 Gaddis in Himachal Pradesh (Registrar General of India 2011) have transitioned out of pastoralism and only a subset of the community continues the traditional practice. This subset, called the *aslibhedpalak* (real pastoralists) by nonpastoral Gaddis, forms the focus of this research.

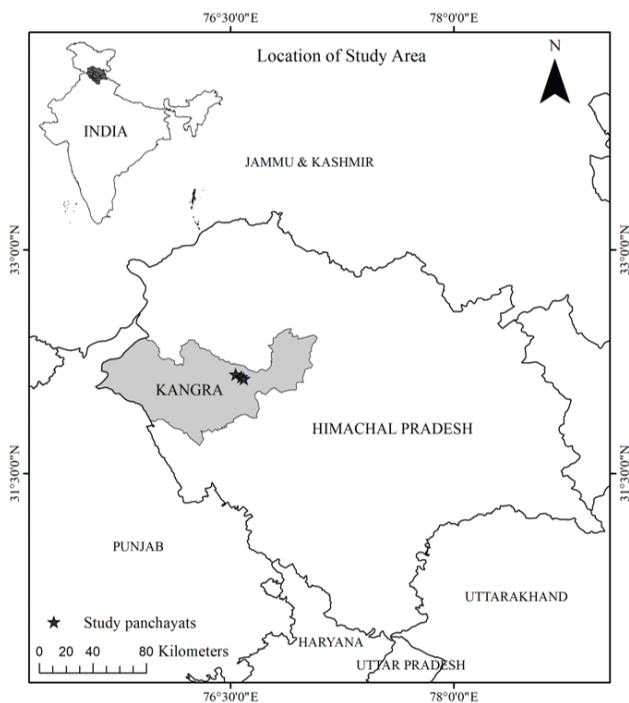
The Gaddis are a well-studied community; scholarship on Gaddis has documented the dynamics of kinship relations (Kapila 2004, 2008), lives and profession (Barnes 1850, Lyall 1874), migratory pattern and human ecology (Noble 1987, Bhasin 1998, Chakravarty-Kaul 1998), history (Sharma 2015), conflicts and negotiations with colonial state and postcolonial India's government (Saberwal 1999), survival in and management of common property forests and pastures (Chakravarty-Kaul 1996, Axelby 2007), and life beyond pastoralism (Wagner 2013). However, there is little research that links their current predicament to the broad set of social and biophysical factors, including widespread government-run afforestation programs that have affected the region since at least the 1970s. This body of work needs updates to examine the newer ways that Gaddi land

Table 2. Plantations in the study area.[†]

Panchayat (village council)	Plantation area (ha)	Number of plantations	Number of current plantations previously used as pasture	In surveyed plantations, incidence of			Occurrence of main species in plantations			
				Fire	Grazing	Invasive	Chir pine	Robinia	Deodar	Ban (oak species)
Spedu	258	23 (8)	13	1	7	3	7	8	11	14
Chandpur	127	15 (8)	11	7	8	7	14	2	4	4
Thala	273	26 (13)	12	12	8	13	25	1	7	9

[†] Surveyed plantations shown in ().

Fig. 2. Map of study area in Himachal Pradesh, India.

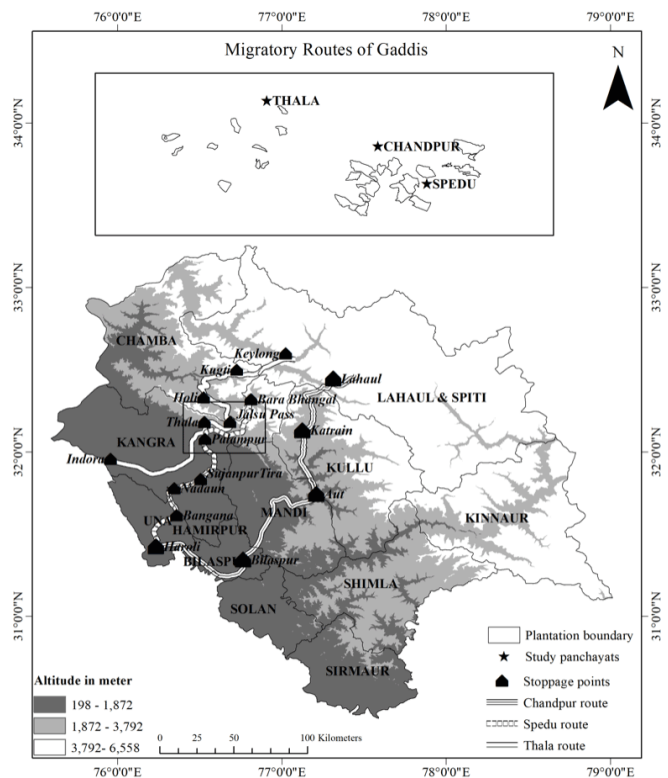


use relationships are shaped by forest policy, and more broadly how Gaddi livelihoods are changing within broader drivers of pastoralism.

METHODS

We followed a mixed-methods approach that combined ethnographic fieldwork and ecological surveys. The sampling design of the *panchayats* (local government units) was based on a larger study that randomly selected 60 *panchayats* and their plantations in four forest department ranges of Kangra district. In the ethnographic component, we used a purposive design strategy to sample three *panchayats* that have large Gaddi populations and key informants ($n = 57$) who were most knowledgeable about the specific conditions of Gaddi vulnerability and resilience. We used this design to obtain a range of perspectives, understand conditions of pastoral livelihoods, and identify the interaction of plantations within the broad set of drivers influencing pastoralism.

Fig. 3. Map of migratory routes of Gaddis and plantations in study area.



Between June 2018 and February 2019, we conducted semistructured interviews with herders in Chandpur and Thala *panchayats* of Palampur tehsil and Spedu *panchayat* in Baijnath tehsil in Kangra district (Fig. 3). We interviewed both Gaddis who practice pastoralism and those who have transitioned to alternate livelihoods ($n = 23$), and interviewed three herders in their winter *dera* (resting places with corrals) along the migratory routes. From the 23 key informants, we conducted in-depth, open-ended interviews with the following respondents (anonymized names): Thimpu and Govind Jeet (herder) and Parma Singh (former herder, now shopkeeper) in Chandpur; Ratna Devi (herder) in Thala and Musafir Ram (former herder, now wage laborer) in Spedu; Saraf Singh (former herder, now farmer), Uddam Singh (former herder, now meat trader), and Sant Ram (herder) in Lapiana. During these meetings, we solicited information on

institutions critical to pastoralism and subsequently interviewed *panchayat* representatives in all three study *panchayats* ($n = 6$), forest department officials at multiple levels of administration and jurisdiction ($n = 10$), Wool Federation representatives ($n = 3$), veterinary doctors ($n = 3$), leaders of the Gaddi Union ($n = 2$) and Gaddi Kalyan Board ($n = 4$), and traders of meat and wool ($n = 3$) in Dramman, one of the main markets for Gaddis.

We built narratives of plantation-pastoralist interactions based on detailed interviews with Gaddi and institutional key informants and triangulated responses and considered our sample complete when no new analytical information was presented. In the ecological component, we relied on key informants and forest department records to list all plantations in the three study *panchayats*. We found a total 64 plantations covering 658 hectares across the three *panchayats* that were planted between 1960 and 2017 (Table 2). We gathered the spatial location and main species for each plantation, along with information about the government programs responsible for the plantation and the relationship of the plantation to local governance institutions. Because it was not possible to survey the entire migratory route for plantation activity, we circumscribed our ecological survey to the three study *panchayats* where we randomly selected plantations that were larger than 5 ha and that were planted after 1980, as well as all those planted in 2017. These plantations were mapped and dominant species planted, canopy cover, evidence of disturbance, biophysical attributes, and human activity recorded.

RESULTS

Based on multiple interviews and contextualization of results, we present experiences of Gaddi herders over the years, focusing on plantations as one of the emerging drivers of changes in pastoralism. Although we acknowledge the wide spectrum of social, political, economic, and environmental drivers that can influence livelihoods, our focus is on the impact of plantations within the broader array of social and biophysical factors.

Like pastoralists worldwide (Robinson and Berkes 2010, Reid et al. 2014, Dong et al. 2016, Unks et al. 2019) Gaddis are increasingly shifting away from pastoral livelihoods. They are settling in villages near winter pastures and gaining alternate employment as laborers, soldiers, teachers, and traders. They are also capitalizing on government policies that promote sedentarization such as subsidies for stall-fed jersey cows (see Agrawal 1999, Robbins 2004 for discussion of similar adaptations by *Raika* shepherds of Rajasthan). However, when pastoralists become sedentary to secure tenure rights to grazing lands, they lose the flexibility to use multiple land types by mobility during times of scarcity (Reid et al. 2014), which reinforces the importance of alternate livelihoods. We find that sedentarization becomes tightly coupled to diversification of incomes and increased dependence on alternate livelihoods to supplement loss of income from decreased livestock production. Conversely, flexibility to ensure access to grazing areas requires mobility and focused attention on pastoral livelihood, which would decrease the ability to diversify across income streams. Of the 23 Gaddi households studied, seven have transitioned to nonpastoral livelihoods including employment in government and private jobs, with the army, or as laborers. They note a pattern consistent with broader livelihood trends: Gaddi livelihood changes have been away from pastoralism and natural-resource dependent activities.

Everyday lives of Gaddis

The Gaddi pastoral ecosystem is best described as a complex mosaic (Robinson 2019) that conforms to neither conventional commons nor open access property regimes. Gaddi ecosystems are a mix of land uses where social processes other than property rights institutions plays a prominent role. Based out of villages located at middle elevations, they use migratory paths (Fig. 3) to access the high altitudinal pastures in summers, dry landscapes in monsoons, and back to their home villages in winters. These migratory patterns have been made through decades of pastoral experience in navigating landscapes. Pastoral lives are inherently difficult. Everyday challenges include theft of animals, lightning strikes, landslides, rapidly changing glacial conditions, and wildlife attacks, especially from black bears. Gaddis rely on “primitive technologies” and autonomous adaptation strategies to cope with threats. Narratives of the unlucky Gaddi who was violently attacked by thieves, fell off a bridge in pouring rain, slipped into a glacial ravine, lost his flock in a lightning strike, or who was mauled by a bear are frequent.

The main income streams of Gaddi pastoral livelihoods are from selling (1) sheep wool thrice a year, (2) goats and sheep for meat, typically male animals, excluding those reared for breeding or those that cannot migrate, e.g., young, sick, and injured animals, and (3) skin of goats. Sometimes, Gaddis sell pups of their shepherd dogs. In our study area, an average Gaddi household maintains up to 250 goats and sheep and earns between INR 250000 (US\$3525, at 0.0141 conversion rate) to INR 300000 (US\$4230) gross income each year from livestock rearing. Gaddi families also practice rainfed agriculture growing maize, rice, and legumes in middle altitude base villages to which migratory pastoralists return during the primary growing season.

A mix of colonial and contemporary formal and informal institutions govern Gaddi pastoralism. Formal institutions include government departments: forest, revenue, police, veterinary, and animal husbandry; civic welfare institutions: Gaddi Union, the Gaddi Kalyan Board, and a few other similar NGOs; market institutions: Wool Federation, insurance providers, meat markets; elected bodies at the local level such as the *panchayat* and higher level elected representatives, and formal policies of note such as the permit system for access to grazing lands, Forest Rights Act (2006), and Livestock Policy (2013). Informal “adjustments” among herders, with *puhals* (laborers), and between herders and landowners, cultural and symbolic institutions, and social exchange-based obligations constitute the informal landscape.

Land use types accessed by Gaddis

Gaddis use four types of land in a complex agro-pastoral mosaic: (1) forests, (2) high-altitude commons, (3) village commons, and (4) private land owned by farmers. The forests and high-altitude commons require permits to be issued by the forest department and other responsible government officials. The permission to graze on village commons is obtained from local landowners and institutions, while the private lands are accessed through customary relations between Gaddis and individual farmers. Figure 3 shows the migratory routes used by Gaddis in three different villages in our study area, including the four land types distributed across three altitudinal zones in Himachal Pradesh: low altitude zones in Kangra and Una districts, midaltitudinal

Fig. 4. Land use types accessed by pastoralists and focus of plantation activity.

	Plantations				
Land types	Reserved forest (<i>jungle</i>)	Demarcated protected forest (<i>jungle</i>)	Undemarcated protected (<i>dhar</i>), unclassified (<i>jungle</i>), degraded forest (<i>jungle</i>)	Village commons	Private land
Gaddis' access dimensions	No access, special permits, illegal access, political intervention	Permits, restricted access in new plantations, illegal access, political intervention	Permits, restricted in new plantations, illegal access, political intervention	Access with rights, negotiated access, restricted in new plantations	Negotiated access, exchange-based, obligations

zones in Chamba, Kangra, Kullu, and Mandi districts, and the high altitudinal zones in Kangra and Lahaul and Spiti district. Typically, every herder has a permit for an individual *dhar* (pasture land) and several *jungles* (forest types, also called *ban*) issued by the forest department, which provides access to several types of land for grazing throughout the migratory route. Figure 4 explains the access dimensions in each of the land types. Adding to Axelby (2007) who provides examples and explanation of communal pooling of permits and negotiations, we found that an individual permit allows for cutting of branches (*dali*) of 2.5 cm, harvest 120 kg fuelwood per day, and staying in other Gaddi's permit forest for one night. Coupled with restrictions corresponding to plantation areas, the access to grazing lands becomes fraught with uncertainties. Our focus in this paper is on the overlapping space between plantations and grazing land accessed by Gaddis, as represented in Figure 4. Our key observations and arguments are based on the interaction of plantation drivers and pastoralism on different land types, as traced in the next section.

Plantations make pastoral livelihoods more vulnerable

Plantations make Gaddi livelihoods more vulnerable via three pathways related to species composition, land closure, and access. First, plantations replace fodder species with nonpalatable trees and invasive shrubs. Shifts in resource availability influence livestock health. Second, plantations are hard fenced for the first four to five years after planting, restricting access to fodder. This leads to uncertainty in which areas along the route will become closed in the future, influencing mobility decisions. Third, new plantations compel renegotiating access to alternate fodder sources. Together with broader drivers, these three pathways influence income, labor, expenditure, and contribute to livelihood decisions. Without adequate institutional support to cope with emerging plantation-related and historical drivers of livelihood change, pastoralism is made vulnerable pushing Gaddis toward alternate livelihoods. We propose that the ability to adapt alternate livelihoods and substitute among income streams differentiates which Gaddi herders are vulnerable and who are not. Abilities are in turn structured by legal rights, ability to work between institutional interstices, and power to gain access to fodder on alternate land uses.

Decreasing fodder and invasive plants

Plantations decrease fodder availability directly by planting nonpalatable tree species, and also provide habitats for invasive

shrubs that decrease livestock health and growth. Invasive unpalatable shrubs such as *Lantana camerata* are widely associated with plantation areas. And, *Lantana* invasion is the foremost impact of plantations identified by Gaddis and follows a trend noted earlier (Saberwal 1996, Chakravarty-Kaul 1998). *Lantana* was introduced into Asia and other parts of the world as an ornamental plant, and has become one of the most aggressive weeds in the world (Kohli et al. 2004, Sundaram and Hiremath 2011). It is unpalatable even to goats and forms dense thickets that are difficult to move through and excludes the growth of other shrubs or trees. Genetically diverse and plastic, *Lantana* adapts to a wide variety of habitats especially disturbance-prone areas. New plantation areas cleared of vegetation and dug for planting saplings, or covered by an overstory of pyrophytic species such as Chir pine make prime areas for *Lantana* invasion. Unlike grasses, *Lantana*, grows under Chir pine's thick leaf litter. Aided by its allelopathic effects, it competes with resident biota dominating the understory of forests and plantations. *Lantana*'s copious seeds are dispersed by a wide variety of dispersal agents from birds and insects to water and grazing animals. These characteristics have made *Lantana* successful in invading large parts of India, including Kangra and lower foothills of the Himalayas. Narratives from all interviews suggest that the spread of invasives has intensified over the years, particularly in winter grazing grounds.

The experience of the Chand family in Thala remains a cautionary tale for many Gaddis. Ratna Devi, daughter-in-law of Kamal Chand, who had left with Ratna Devi's husband to their monsoon pastures in Keylong, Lahaul and Spiti narrated, as she worked in a small patch of land behind her house:

[L]ast year, in one of our winter pastures located in Dadasibba near Dehra Gopipur (in Kangra), next to the river Beas, 180 of the 250 goats and sheep of our flock became ill from grazing on a foreign species and died at once. We were not able to identify the species. At the time, we had become completely helpless and did not know what to do further.

Despite this shock, her father-in-law "was very firm that they continue migratory herding" and invested again in goats and sheep. She identified three broad reasons for the continuation of pastoral livelihood, which might have altered livelihood strategies of another family. First, the family, one of the oldest herding

families in Thala, had more confidence in traditionally acquired herding skills than any another livelihood, making shifting to other livelihoods challenging. Second, selling their remaining flock of 70 goats and sheep would have provided only a modest one-time sum in the short term with no further returns, making them vulnerable in the long run. Last, the strong cultural association of herding in the family led them to believe that shifting to alternate livelihoods would earn them disrespect among the community as had happened to another Gaddi in the village. To cope with the shock the Chand family supplemented the 70 animals left over with 50 goats borrowed from a fellow Gaddi herder. They arranged with the other herder to repay 50 goats and sheep and 10 goats as interest that will enable them to eventually rebuild their herd. In response, other Gaddis have also resorted to selling almost all young goats and sheep prior to their winter migration. This is because, as Musafir Ram noted the “young ones are more susceptible to harm from invasives.” They have also forced Gaddis to adapt by modulating their herd composition by shifting toward rearing more goats than sheep, since they can “trample over” *Lantana* and sheep wool gets tangled more easily in *Lantana* bushes leading to decreased incomes. This suggests that when substitutability among livelihoods is not possible, pastoral livelihoods can continue to provide well-being while being exposed to multiple drivers of change - as is well documented in the rich pastoral resilience scholarship (Saberwal 1996, Robinson and Berkes 2010, Dong 2017, Mattalia et al. 2018, Unks et al. 2019). However, it is less clear if pastoral livelihoods are continued because of resilience of pastoralists or because alternatives are not available.

Plantation policy and changing vegetation composition

Analysis of afforestation policy shows that the vast majority of trees planted by the forest department in the last 40 years have been unpalatable to livestock, and the proportion of trees planted that are palatable has declined over time, from 28% in the 1980s to only 20% between 2009 and 2015 (Table 1). This change has occurred even as the total area planted per year has declined, and there has been a limited shift away from commercially oriented trees, e.g., such as Pine, and toward a variety of broad-leaved native species. Govind Jeet’s observation confirms this decrease:

{W}we (herders) have noticed that grasses such as garna [*Carissa diffusa*], basoti [*Adhatoda vasica*], and plants such as peepal [*Ficus religiosa*], kangu [*Flacourtia indica*] are now almost absent in winter pastures. Garna is a favorite among goats and used to constitute an important part of their diet.

The 1980s and 1990s saw intense planting programs such as the Dhauladhar Project and Van Lagao Rozi Kamao (plant trees, earn livelihood) scheme, which planted conifers, mainly Chir pine, Deodar, and spruces in the study area. Interviews with key informants suggest that, of the 64 plantations, 36 had no trees prior to planting and were used exclusively as pastures. Of the 29 surveyed plantations, we found incidence of grazing in 23, fire in 20, and invasive shrubs in 23 plantations (Table 2). Across all *panchayats*, local groups rarely managed plantations except in Spedu where a *Mahila Mandal* (women’s group) has adopted a plantation and enforces grazing restrictions and in Chandpur where a village community monitors grazing. In Spedu, the forest department excluded portions of a migratory corridor from

plantations activity to facilitate easy passage to high altitude pastures. Although this intervention appears to have benefitted herders, our respondents suggest it was an exception, and at the time of plantation, powerful elites were able to coerce the department into making this pathway.

Beginning in the 1990s, the forest department shifted away from commercial production toward a greater emphasis on joint-forest management (Springate-Baginski and Blaikie 2007, Lele and Menon 2014), which has resulted in a shift toward an array of broad-leaved (but still not palatable) species being planted, especially in lower altitudes. However, interviews suggest that Gaddis were largely left out of many joint forest management schemes mainly because of their migratory practice and were consulted in a “token fashion” for compensatory afforestation for hydroelectric projects in high altitudes. Respondents, including forest department representatives, reported that Gaddis were “never consulted” prior to plantation activity either along migratory routes or settlements in winter pastures for choice of species, closures, planning for alternate grazing areas, and sanctions for rule breaking. Instead, forest department and local forest institutions blamed them for forest degradation.

We find this gap between spatially rooted local governance institutions—local administrative units, forest committees, *panchayats*, and village councils—and the mobile lifestyles of pastoralists leads to negative outcomes for both pastoralists and plantations. For example, Uddam Singh cited the example of a 10-hectare patch near his home in Lapiana in lower Kangra where he has witnessed “five to six closures and plantations in the last 20 years, of which two trees, a *Sagban* (teak) and a bamboo, remain standing.” Singh said this failure was both a result of a lack of ecological fit of plantation species and Gaddis intentionally grazing tree seedlings as a resistance against the forest department. The trend toward more inclusive forestry, while ironically excluding communities that are most dependent on forest land, presents challenges for both the department and Gaddis. Although the forest department restricts prime grazing areas by plantations to keep Gaddis away, Gaddis resort to diverse strategies to graze on or around new plantations, both with the immediate aim of obtaining fodder and the long-term aim of halting the plantations.

Fences and restricted mobility

Fencing has been used as an afforestation practice in India to increase survivorship of planted tree saplings in new plantations. Fodder thriving within fenced plantation areas becomes available between removal of fences and canopy closure, and is mostly harvested by hand. Records of plantations show that closures in the Dhauladhar project lasted up to 15 years, while in recent afforestation projects such as Pasture Development or Fuelwood and Fodder project, closures are no more than five years. Forest department officials routinely state a contradiction that fences are installed for the “benefit of people living nearby and for herders” by keeping them “away, and out of reach of themselves.” Fencing closely precedes or is done simultaneously with planting, offering the first clear signal to the community to “keep off” the land. Forest officials often state that the fence is designed to “keep away animals, especially goats.” Survivorship is a key metric in forest department performance evaluations that is used to justify allocation of government funds toward future forest

management. Any decrease in survivorship is blamed on pastoralists and local communities who “cut fences and let their animals free” and on goats that “do not spare a fresh leaf.” Although some herders agree that their *maal* (livestock) do venture into fenced plantations, they explain how it is not always intentional. “They (livestock) do not see the fence.” The attitudes of individual herders toward fencing varies, with some intentionally trying to obstruct plantations, and others favoring them, although aware that their goats may graze them by mistake.

Along with intentional grazing observed in the previous paragraph, contrasting narratives within the Gaddi and forest department community play out across the study area and along the migratory routes where fences made up of bamboo, concrete, or tree boles of three to five feet and barbed wire protect plantations. Even though Gaddis are receptive when lands become closed and when they will become open, fence removal is often unpredictable. Moreover, recent afforestation practices that include live fences composed of unpalatable species can harm livestock. “When goats eat them, they get sick, and it is easier for me to sell them rather than take them to the doctor.” The unpredictability of installation and removal of fences and the harm to livestock caused by fences push Gaddis away from plantation areas and they become more dependent on other lands (Fig. 4) such as private lands and village commons. Furthermore, migratory routes are now increasingly disrupted by growing towns and peri-urban developments, hydroelectric projects, widening and metering of roads, and intensified traffic due to tourism. For example, in one important migratory passage between Do-nali and Bharmour, plantations on either side of the road left “no space for herds, forcing movement throughout the night to decrease clashes with traffic.” Gaddis have responded to changing conditions by altering their migratory routes. They either shorten their migration—some herders in Spedu do not go all the way to Lahual and Spiti in summer—or shift routes to other areas in neighboring Mandi district. Herders note that planning for stoppage points along the route either in make-shift tents with corrals (*dera* and *tapri* in low- and high-altitude, respectively) require more “strategy and becoming bold.”

Drawing on political connections

Earlier research identified the ability of Gaddis to manage institutional interstices, use conflicts among government institutions to their advantage, and deploy the durable perception of Gaddi as a victim of state policy to their advantage (Chakravarty-Kaul 1996, Agrawal and Saberwal 2004, Axelby 2007). This study also found that Gaddis use a number of formal and informal mechanisms to access common pastures. Formally, most common pastures require annual permits from the forest department; however the costs of these permits were set in the early 20th century (Saberwal 1996). Even though permit prices have marginally increased from 0.5 INR/goat, 0.18 INR/sheep to 0.7 INR/goat and 0.45 INR/sheep, herders are able to afford the cost. Pastoralists interviewed in this study paid less than INR 500 for a year, while the price of meat is INR 320/Kg. Gaddis take advantage of highly uneven enforcement of permit regulations, often relying on outdated permits, illegally selling permits to other herders, traveling in family groups that are larger than those permitted, or halting in temporary grazing sites for longer than allowed. Although the forest department is aware of these practices, Gaddis also have accumulated significant political

power, and are thus able to evade enforcement even when their activities clearly flout the law. Lower elevation pastures, where most plantation activity is occurring, are also where the forest department enforces rules more actively, making these areas particularly difficult to access. Because of this, Gaddis have continued to purchase land and settle in lower Kangra in order to access village commons and/or resort to illegal grazing in protected forests. This puts strain on a limited area, increasing the chances of overgrazing. Saraf Singh explained one example of negotiating access in the context of permit renewal, which shows how Gaddis have learned to work state institutions to their advantage and how the disconnect in governance has grown wider:

I went to the meyhakma (department, refers to forest department) last year to renew my permit. The new guard (block officer) wrote a letter that resembled a school application (laughs). He had no idea what a permit looked like. When I told him humbly, “Sir, all that you need to mention is the dhar, the jungle, the number of animals and my name, which is written here in my permit,” he got angry and dismissed me as an imbecile. He went to the range officer who scolded him at once. He repeated the same process again and was insulted in front of all visitors by the range officer. Then he changed tune and asked me meekly “hey, what should I write here?” Then I told him what I had been telling all along. Some Gaddis renew with new jungles or even band jungle (restricted) listed, but they cannot change the number of animals, some officers do not even know that and ask what should I change? These new meyhakma people know nothing of the history of the Gaddis and our life.

Gaddis draw on their political power to cope with challenges of negotiating access and addressing livestock theft. Earlier findings showed how Gaddis skillfully deployed a mix of traditional kinship networks (Kapila 2004), established social exchange patterns with cultivators and markets (Chakravarty-Kaul 1998, Kapila 2004, Axelby 2007) to create identity-based political movements (Saberwal 1996, Bhasin 1998) at politically sensitive times to sustain their pastoral livelihood. Remnants of those movements help herders cope with current risks. For example, Sant Ram told us that “we could call our representative, (a former forest minister from Bharmour) and complain of harassment or theft. The thieves would be caught in no time and we would be compensated.” This process of drawing on political connections has been put to effective use by Gaddis in negotiating access to some *jungle* areas as well. For example, in cases when two to three months’ permit for grazing in a protected forest or in areas that are now declared as “sanctuary” is required, or the permits are inconclusive on forest areas, calls from politicians pressure forest department officials into allowing grazing.

Changing access dimensions

Plantations along with broader socioeconomic and agricultural shifts reshape access relationships with the forest department, which holds rights on forests and pastures and local institutions managing village commons and individuals (Fig. 4). In examining whether access relationships are in favor or against Gaddis in each land use type, respondents report an overall shift that systematically weighs against them. We find that access

relationships with government has more or less remained unchanged with restricted access in reserve forests, no access in new plantations and permit-based access in some un-demarcated forests. Notwithstanding these legal types of access, illegal access and political intervention-based access also assist Gaddis in securing fodder, as explained earlier. The increased dependence on village commons and private land however pose other challenges including plantation activity and increased competition from local livestock owners, requiring negotiating with *panchayats* and forest committees.

Access relationships on private lands are situated within a broader shift from agro-pastoralism toward horticulture, which has decreased fodder from postharvest wheat, maize, and rice. Although farmers once welcomed pastoral herders to their fallow grain fields to eat stubble and fertilize the fields with manure, farmers now grow crops that leave little stubble, are not compatible with postharvest grazing, and rely on chemical fertilizer rather than manure. Markets for horticultural crops have grown both regionally, due to increased tourism, and nationally, while crop raiding wildlife, which some farmers report are encouraged by plantations, have further encouraged a shift to fruit orchards. Policies that heavily subsidize solar electric fencing to keep out boars and other wildlife also keep out Gaddi herds, and herders who once accessed fields for free now must negotiate a payment to access fodder in fenced farmland. What was earlier a privileged exchange in favor of Gaddi herds, where farmers competed for manure from passing herds, progressively changed from social exchange of manure for fodder (Saberwal 1996) to Gaddis pursuing market exchange by purchasing fodder from cultivators. Thimpu from Chandpur explains:

[E]arlier, goats and sheep used to graze on malkits (private agricultural lands) during summer season. With the cultivation of horticultural crops, the farmers are now wary about damage to their crop from a grazing herd. We now have to keep our goats and sheep away from agricultural land or pay farmers in exchange for receiving fodder.

Other challenges specific to Gaddi pastoralism further increase the vulnerability of their livelihoods. Organized theft is a rising problem. Attacks on Gaddis by armed criminals have endangered Gaddi individuals and their shepherd dogs. Herders told us about criminals using chemical sprays to immobilize dogs, along with heavy transport vehicles and weapons to steal large number of animals. In addition, interviews suggested that “most current herders are over 50 years old and lead solitary existence like a *baba* or saint.” Such herders are at risk from becoming ill and not receiving healthcare on time. The decline of pastoral livelihoods has also put a variety of associated livelihoods, such as meat traders, laborers, butchers, and wool traders, at risk. Some of these associated livelihoods are severely threatened by other broader drivers as well. For example, respondents note that traditional wool weavers have adapted to alternate livelihoods since markets prefer machine-spun imported wool to the coarse hand-spun wool sold by Gaddis.

DISCUSSION

The result of these multiple livelihood stressors is a decline in livestock-based pastoral livelihoods and shift toward alternate income sources. The move away from pastoral livelihoods has four

potential consequences. First, this can lead to reduced resource extraction and potentially result in environmental conservation. For example, if Gaddi-owned goats overgraze pastures and suppress tree regeneration in forests, as forest department officials often claim, the reduced grazing pressure (resulting from Gaddi disinvestment in livestock) could increase regeneration. Second, human use also maintains ecosystems. For example, grazing and browsing by ruminants is essential for maintaining many savanna ecosystems (Ratnam et al. 2011, Bond et al. 2019, Kumar et al. 2020). Thus, the loss of Gaddi livestock could result in degradation of ecosystems that are dependent on Gaddi livestock for preventing ingrowth of woody plants by grazing and/or for redistributing nutrients. Third, human institutions that maintain ecosystem processes will change. If herders previously defended their grazing rights, in the absence of herders it may be easier for others to claim those lands for mining or hydropower development. Finally, although former migratory Gaddi households are no longer as dependent on forests for livestock grazing, they are still dependent on village commons for fuel or sourcing their necessities from nearby markets. In this case, it may simply result in environmental degradation of alternate resources.

A key observation in our study area is the varied abilities of Gaddis to diversify income sources governed by education, social networks, age of family members, and other cultural factors. This is central to differentiating the vulnerability of individuals and the vulnerability of livestock-based pastoral livelihoods as our framework suggests. Although it is clear that the distinction is important in pastoralist economy and livelihood analysis broadly, it is necessary to examine the extent to which drivers of livelihood change and individual vulnerability influence precarity among pastoralists. For example, it is difficult to identify which abilities assisted in the transition of those Gaddis who transitioned to alternate livelihoods. An integrated approach as presented here would help hypothesize the conjoint effects of social-structural, biophysical, and emerging stressors on livelihood change, which contrasts with explanations that propose individual stressors as main drivers of change. Because pastoralists consistently face disadvantage even with apparently well-developed access mechanisms and political tools, and pastoral ecosystems change because of afforestation, the uneven ability that makes alternate livelihoods possible and pastoralism resilient is an arena that needs careful analysis. For example, the ability to sustain pastoralism in the face of plantation risks is structured by legal rights to pastures, the ability to work between institutional interstices, and the power to gain access to fodder on alternate land uses. We need more attention on the ability of those individuals who continue pastoralism in the face of outward transitions, on the ecological effects of such shifts, and on the pathways through which their vulnerability is produced. Plantations are just one of the pathways to Gaddi vulnerability: they create hard boundaries, change species, and influence mobility and access.

Forest policies in our study area have largely ignored Gaddi livelihoods. Higher level governance institutions need to address this gap in local governance, because studies have consistently highlighted that spatially bounded local governments fail to capture and support the benefits of migratory lifestyles (Saberwal 1997, Springate-Baginski and Blaikie 2007). Although our

qualitative research design is inadequate to assess the relative importance of plantations compared to other factors and the magnitude of interactions between factors, we document that plantations contribute to changes in pastoral livelihoods in ways that have not been mentioned in previous studies of pastoral livelihoods, and are likely to grow in significance globally, based on the growing investment in plantation forestry. Furthermore, although many of the factors negatively affecting pastoral livelihoods are not amenable to simple policy solutions, plantations, such as those affecting Gaddi pastoralists in Himachal Pradesh, are entirely policy-driven, and thus modifications in the design and implementation of plantations could be an effective way to support pastoral livelihoods. Because grazing is often mentioned by forest officials as one of the most significant threats to plantation survivorship, alleviating conflict with pastoral communities could also contribute to greater plantation success. Working with pastoralists to plant palatable species in grazing areas and/or prioritize plantations away from migratory corridors and toward less productive pastures could be effective ways to mitigate conflicts between plantations and pastoralists.

CONCLUSION

We show how current afforestation practices enhance the vulnerabilities of declining pastoral livelihoods and how Gaddis are unable to influence the nature of afforestation programs that occur in parts of their winter migratory routes. We demonstrate that plantations are an important influence in pastoral livelihoods because of their social and ecological effects, and that plantations are particularly important in reshaping access to land. Plantations have an opportunity to serve a larger purpose of increasing resilience of vulnerable livelihoods, in addition to increasing forest cover. They present an easier solution to sustain pastoralism compared to addressing other important, but recalcitrant drivers of livelihood change such as land fragmentation, inequality and uneven access to economic opportunities, and impacts of climate change. We find that these opportunities can be realized when pastoralists have enhanced roles in afforestation activity. We encourage the development of policy that increases representation of Gaddis in afforestation to minimize negative impacts, targets vulnerable livelihoods associated with pastoralism, and reviews the antiquated permit system. We hope that these cases lead to additional research that makes robust links between debates surrounding afforestation and questions related to pastoralism, sustainability of plantations and the ecosystems they are embedded in, and the ability of individuals to continue pastoral livelihoods.

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/issues/responses.php/11810>

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Data Availability:

Data underlying the findings described in this manuscript are available at the University of Minnesota's Data Repository. Persistent link to this item: <http://hdl.handle.net/11299/214818>.

LITERATURE CITED

- Adams, C., S. T. Rodrigues, M. Calmon, and C. Kumar. 2016. Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know. *Biotropica* 48:731-744. <https://doi.org/10.1111/btp.12385>
- Agrawal, A. 1999. *Greener pastures: politics, markets, and community among a migrant pastoral people*. Duke University Press, Durham, North Carolina, USA.
- Agrawal, A., D. Nepstad, and A. Chhatre. 2011. Reducing emissions from deforestation and forest degradation. *Annual Review of Environment and Resources* 36:373-396. <https://doi.org/10.1146/annurev-environ-042009-094508>
- Agrawal, A., and V. K. Saberwal. 2004. Whither South Asian pastoralism? An introduction. *Nomadic Peoples* 8:36-53. <https://doi.org/10.3167/082279404780446113>
- Andersson, K., D. Lawrence, J. Zavaleta, and M. R. Guariguata. 2016. More trees, more poverty? The socioeconomic effects of tree plantations in Chile, 2001-2011. *Environmental Management* 57:123-136. <https://doi.org/10.1007/s00267-015-0594-x>
- Axelby, R. 2007. 'It takes two hands to clap': how Gaddi shepherds in the Indian Himalayas negotiate access to grazing. *Journal of Agrarian Change* 7:35-75. <https://doi.org/10.1111/j.1471-0366.2007.00139.x>
- Balachandran, M. 2016. India plans to spend \$6 billion on creating new forests. *QuartzIndia*, 5 May. [online] URL: <https://qz.com/india/675910/india-plans-to-spend-6-billion-on-creating-new-forests/>
- Balthazar, V., V. Vanacker, A. Molina, and E. F. Lambin. 2015. Impacts of forest cover change on ecosystem services in high Andean mountains. *Ecological Indicators* 48:63-75. <https://doi.org/10.1016/j.ecolind.2014.07.043>
- Barnes, G. C. 1850. *Report of the land revenue settlement of the Kangra District*. Chronicle, Lahore, Pakistan.
- Bhasin, V. 1998. *Himalayan ecology, transhumance and social organisation; Gaddis of Himachal Pradesh*. Kamla-Raj Enterprises, Delhi, India.
- Blaikie, P., T. Cannon, I. Davis, and B. Wisner. 1994. *At risk. Natural hazards, people's vulnerability and disasters*. Routledge, London, UK.

- Bond, W. J., N. Stevens, G. F. Midgley, and C. E. R. Lehmann. 2019. The trouble with trees: afforestation plans for Africa. *Trends in Ecology & Evolution* 34:963-965. <https://doi.org/10.1016/j.tree.2019.08.003>
- Bremer, L. L., and K. A. Farley. 2010. Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness. *Biodiversity and Conservation* 19:3893-3915. <https://doi.org/10.1007/s10531-010-9936-4>
- Chakravarty-Kaul, M. 1996. *Common lands and customary law: institutional change in north India over the past two centuries*. Oxford University Press, Oxford, UK.
- Chakravarty-Kaul, M. 1998. Transhumance and customary pastoral rights in Himachal Pradesh: claiming the high pastures for Gaddis. *Mountain Research and Development* 18:5-17. <https://doi.org/10.2307/3673864>
- Chambers, R., and G. Conway. 1992. *Sustainable rural livelihoods: practical concepts for the 21st century*. Institute of Development Studies, Brighton, UK.
- Crouzeilles, R., M. Curran, M. S. Ferreira, D. B. Lindenmayer, C. E. V Grelle, and J. M. Rey Benayas. 2016. A global meta-analysis on the ecological drivers of forest restoration success. *Nature Communications* 7:11666. <https://doi.org/10.1038/ncomms11666>
- Davis, D. K., and P. Robbins. 2018. Ecologies of the colonial present: pathological forestry from the *taux de boisement* to civilized plantations. *Environment and Planning E: Nature and Space* 1:447-469. <https://doi.org/10.1177/2514848618812029>
- Dong, S. 2017. Himalayan grasslands: Indigenous knowledge and institutions for social innovation. Pages 99-126 in S. Dong, J. Bandyopadhyay, and S. Chaturvedi, editors. *Environmental sustainability from the Himalayas to the oceans: struggles and innovations in China and India*. Springer International, Cham, Switzerland. https://doi.org/10.1007/978-3-319-44037-8_5
- Dong, S., K.-A. S. Kassam, J. F. Tourrand, and R. B. Boone. 2016. *Building resilience of human-natural systems of pastoralism in the developing world*. Springer International, Cham, Switzerland. <https://doi.org/10.1007/978-3-319-30732-9>
- Ellis, F. 2000. The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics* 51:289-302. <https://doi.org/10.1111/j.1477-9552.2000.tb01229.x>
- Fleischman, F. D. 2014. Why do foresters plant trees? Testing theories of bureaucratic decision-making in central India. *World Development* 62:62-74. <https://doi.org/10.1016/j.worlddev.2014.05.008>
- Füssel, H.-M., and R. J. T. Klein. 2006. Climate change vulnerability assessments: an evolution of conceptual thinking. *Climatic Change* 75:301-329. <https://doi.org/10.1007/s10584-006-0329-3>
- Galvin, K. A. 2009. Transitions: pastoralists living with change. *Annual Review of Anthropology* 38:185-198. <https://doi.org/10.1146/annurev-anthro-091908-164442>
- Gerber, J.-F. 2011. Conflicts over industrial tree plantations in the South: who, how and why? *Global Environmental Change* 21:165-176. <https://doi.org/10.1016/j.gloenvcha.2010.09.005>
- Holl, K. D., and P. H. S. Brancalion. 2020. Tree planting is not a simple solution. *Science* 368:580-581. <https://doi.org/10.1126/science.aba8232>
- Joshi, A. A., M. Sankaran, and J. Ratnam. 2018. 'Foresteering' the grassland: historical management legacies in forest-grassland mosaics in southern India, and lessons for the conservation of tropical grassy biomes. *Biological Conservation* 224:144-152. <https://doi.org/10.1016/j.biocon.2018.05.029>
- Kapila, K. 2004. Conjugating marriage: state legislation and Gaddi kinship. *Contributions to Indian Sociology* 38:379-409. <https://doi.org/10.1177/006996670403800304>
- Kapila, K. 2008. The measure of a tribe: the cultural politics of constitutional reclassification in North India. *Journal of the Royal Anthropological Institute* 14:117-134. <https://doi.org/10.1111/j.1467-9655.2007.00481.x>
- Kohli, R. K., K. S. Dogra, D. R. Batish, and H. P. Singh. 2004. Impact of invasive plants on the structure and composition of natural vegetation of northwestern Indian Himalayas. *Weed Technology* 18:1296-1300. [https://doi.org/10.1614/0890-037X\(2004\)018\[1296:IOIPOT\]2.0.CO;2](https://doi.org/10.1614/0890-037X(2004)018[1296:IOIPOT]2.0.CO;2)
- Kumar, D., M. Pfeiffer, C. Gaillard, L. Langan, C. Martens, and S. Scheiter. 2020. Misinterpretation of Asian savannas as degraded forest can mislead management and conservation policy under climate change. *Biological Conservation* 241:108293. <https://doi.org/10.1016/j.biocon.2019.108293>
- Le, H. D., C. Smith, J. Herbohn, and S. Harrison. 2012. More than just trees: assessing reforestation success in tropical developing countries. *Journal of Rural Studies* 28:5-19. <https://doi.org/10.1016/j.jrurstud.2011.07.006>
- Lele, S. M., and A. Menon. 2014. *Democratizing forest governance in India*. Oxford University Press, New Delhi, India. <https://doi.org/10.1093/acprof:oso/9780198099123.001.0001>
- Lyall, J. B. 1874. *Report of the land revenue settlement of the Kangra District, Panjab, 1865-72*. Printed at Central Jail Press. Government Press, Lahore, Pakistan.
- Malkamäki, A., D. D'Amato, N. J. Hogarth, M. Kanninen, R. Pirard, A. Toppinen, and W. Zhou. 2018. A systematic review of the socio-economic impacts of large-scale tree plantations, worldwide. *Global Environmental Change* 53:90-103. <https://doi.org/10.1016/j.gloenvcha.2018.09.001>
- Marschke, M. J., and F. Berkes. 2006. Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society* 11(1):42. <https://doi.org/10.5751/ES-01730-110142>
- Mattalia, G., G. Volpato, P. Corvo, and A. Pieroni. 2018. Interstitial but resilient: nomadic shepherds in Piedmont (Northwest Italy) amidst spatial and social marginalization. *Human Ecology* 46:747-757. <https://doi.org/10.1007/s10745-018-0024-9>
- Menz, M. H. M., K. W. Dixon, and R. J. Hobbs. 2013. Hurdles and opportunities for landscape-scale restoration. *Science* 339:526-527. <https://doi.org/10.1126/science.1228334>
- Ministry of Environment and Forests. 2010. *National mission for a green India (Under the National Action Plan on Climate Change)*. Draft Submitted to Prime Minister's Council on

- Climate Change, New Delhi, India. [online] URL: <http://www.indiaenvironmentportal.org.in/files/GIM-Report-PMCCC.pdf>
- Noble, C. 1987. *Over the high passes: a year in the Himalayas with the migratory Gaddi shepherds*. Harper Collins, New York, New York, USA.
- O'Brien, K., S. Eriksen, L. P. Nygaard, and A. Schjolden. 2007. Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy* 7:73-88. <https://doi.org/10.1080/14693062.2007.9685639>
- Ojha, H., T. Maraseni, A. Nightingale, B. Bhattarai, and D. Khatri. 2019. Rescuing forests from the carbon trap. *Forest Policy and Economics* 101:15-18. <https://doi.org/10.1016/j.forpol.2019.01.007>
- Ramprasad, V. 2019. Debt and vulnerability: indebtedness, institutions and smallholder agriculture in South India. *Journal of Peasant Studies* 46:1286-1307. <https://doi.org/10.1080/03066-150.2018.1460597>
- Ratnam, J., W. J. Bond, R. J. Fensham, W. A. Hoffmann, S. Archibald, C. E. R. Lehmann, M. T. Anderson, S. I. Higgins, and M. Sankaran. 2011. When is a 'forest' a savanna, and why does it matter? *Global Ecology and Biogeography* 20:653-660. <https://doi.org/10.1111/j.1466-8238.2010.00634.x>
- Ravindranath, N. H., I. K. Murthy, R. K. Chaturvedi, K. Andrasco, and J. A. Sathaye. 2007. Carbon forestry economic mitigation potential in India, by land classification. *Mitigation and Adaptation Strategies for Global Change* 12:1027-1050. <https://doi.org/10.1007/s11027-006-9063-4>
- Registrar General of India, Ministry of Home Affairs. 2011. *Scheduled tribe population by religious community*. Registrar General of India, New Delhi, India.
- Reid, R. S., M. E. Fernández-Giménez, and K. A. Galvin. 2014. Dynamics and resilience of rangelands and pastoral peoples around the globe. *Annual Review of Environment and Resources* 39:217-242. <https://doi.org/10.1146/annurev-environ-020713-163329>
- Ribot, J. 2014. Cause and response: vulnerability and climate in the Anthropocene. *Journal of Peasant Studies* 41:667-705. <https://doi.org/10.1080/03066150.2014.894911>
- Robbins, P. 2004. Pastoralists inside-out: the contradictory conceptual geography of Rajasthan's Raika. *Nomadic Peoples* 8 (2):136-149. <https://doi.org/10.3167/082279404780446032>
- Robinson, L. W. 2019. Open property and complex mosaics: variants in tenure regimes across pastoralist social-ecological systems. *International Journal of the Commons* 13:804-826. <https://doi.org/10.18352/ijc.903>
- Robinson, L. W., and F. Berkes. 2010. Applying resilience thinking to questions of policy for pastoralist systems: lessons from the Gabra of northern Kenya. *Human Ecology* 38:335-350. <https://doi.org/10.1007/s10745-010-9327-1>
- Saberwal, V. K. 1996. Pastoral politics: Gaddi grazing, degradation, and biodiversity conservation in Himachal Pradesh, India. *Conservation Biology* 10:741-749. <https://doi.org/10.1046/j.1523-1739.1996.10030741.x>
- Saberwal, V. K. 1997. Bureaucratic agendas and conservation policy in Himachal Pradesh, 1865-1994. *Indian Economic & Social History Review* 34:465-498. <https://doi.org/10.1177/001946469703400403>
- Saberwal, V. K. 1999. *Pastoral politics: shepherds, bureaucrats, and conservation in the Western Himalaya*. Studies in social ecology and environmental history. Oxford University Press, Delhi, India.
- Sayre, N. F., R. R. J. McAllister, B. T. Bestelmeyer, M. Moritz, and M. D. Turner. 2013. Earth stewardship of rangelands: coping with ecological, economic, and political marginality. *Frontiers in Ecology and the Environment* 11:348-354. <https://doi.org/10.1890/120333>
- Shah, A., J. Lerche, R. Axelby, D. Benbabaali, B. Donegan, J. Raj, and V. Thakur. 2018. *Ground down by growth. Tribe, caste, class, and inequality in twenty-first century India*. Pluto Press and Oxford University Press, Delhi, India.
- Sharma, M. 2015. Ritual, performance, and transmission: the Gaddi shepherds of Himachal Himalayas. *Oral Tradition* 29(2). <https://doi.org/10.1353/ort.2015.0004>
- Springate-Baginski, O., and P. Blaikie. 2007. *Forests people and power: the political ecology of reform in South Asia*. Routledge, London, UK. <https://doi.org/10.4324/9781849771399>
- Stern, N. 2007. *The economics of climate change: the Stern review*. Cambridge University Press, Cambridge, UK. <https://doi.org/10.1017/CBO9780511817434>
- Sundaram, B., and A. J. Hiremath. 2012. *Lantana camara* invasion in a heterogeneous landscape: patterns of spread and correlation with changes in native vegetation. *Biological Invasions* 14:1127-1141. <https://doi.org/10.1007/s10530-011-0144-2>
- The Bonn Challenge. 2016. *The Bonn Challenge*. International Union for the Conservation of Nature, Washington, D.C., USA.
- Turner, B. L., R. E. Kasperson, P. A. Matson, J. J. McCarthy, R. W. Corell, L. Christensen, N. Eckley, J. X. Kasperson, A. Luers, M. L. Martello, C. Polsky, A. Pulsipher, and A. Schiller. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America* 100:8074-8079. <https://doi.org/10.1073/pnas.1231335100>
- Unks, R. R., E. G. King, D. R. Nelson, N. P. Wachira, and L. A. German. 2019. Constraints, multiple stressors, and stratified adaptation: pastoralist livelihood vulnerability in a semi-arid wildlife conservation context in Central Kenya. *Global Environmental Change* 54:124-134. <https://doi.org/10.1016/j.gloenvcha.2018.11.013>
- Veldman, J. W., G. E. Overbeck, D. Negreiros, G. Mahy, S. Le Stradic, G. W. Fernandes, G. Durigan, E. Buisson, F. E. Putz, and W. J. Bond. 2015. Where tree planting and forest expansion are bad for biodiversity and ecosystem services. *BioScience* 65:1011-1018. <https://doi.org/10.1093/biosci/biv118>
- Van Holt, T., M. W. Binford, K. M. Portier, and R. Vergara. 2016. A stand of trees does not a forest make: tree plantations and forest transitions. *Land Use Policy* 56:147-157. <https://doi.org/10.1016/j.landusepol.2016.04.015>
- Wagner, A. 2013. *The Gaddi beyond pastoralism: making place in the Indian Himalayas*. Berghahn Books, New York, New York, USA.
- Xu, J. 2011. China's new forests aren't as green as they seem. *Nature News* 477:371. <https://doi.org/10.1038/477371a>