Chapter 31
Coordinating Environmental Protection and Climate Change Adaptation Policy in Resource-Dependent Communities: A Case Study from the Tibetan Plateau

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Abstract Resource-dependent communities are likely to be disproportionately affected by climate change. Yet, natural resource management policies continue to be developed and implemented without considering climate change adaptation. We highlight that this lack of coordination is potentially harmful to natural resources and resource-dependent communities with an example from the Tibetan Plateau, a region where climate is changing rapidly. Tibetan pastoralists inhabit rangelands that are the focus of recent development and management policies that promote fencing, sedentarization, individual rangeland use rights, and the elimination of grazing in some areas. These policies may have a negative effect on herders' ability to adapt to climate change. China's National Climate Change Programme lists controlling or eliminating grazing in some areas as key for adaptation to climate change, but experimental results indicate that grazing may buffer the rangelands from the negative effects of warming. These findings indicate that policies that support the well-developed strategies of resource-dependent communities for living in uncertain and variable environments can also enhance adaptation of these social and ecological systems to climate change. We conclude that management and environmental protection policies developed separately from climate change policy face increased failure potential and may decrease the ability of natural resources and the communities that depend upon them to successfully adapt to climate change.

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Introduction

Climate change may have the greatest effects on resource-dependent communities, where livelihood activities are tightly coupled to the natural resource base. These communities tend to be economically and politically marginalized within their larger national context, even while their resources make significant contributions to the larger national economy. Rangelands – broadly defined here to include grasslands, shrublands, and tundra ecosystems – comprise almost half of the global land surface (Olson 1994). Rangeland systems provide many ecosystem services, i.e., benefits to people, ranging from valuable products to essential regulation of ecosystem health. For example, rangeland regions provide meat and dairy products, wool, oil and gas reserves, mineral resources, freshwater supplies, wildlife habitat, and opportunities for recreation and tourism. These regions also regulate climate, soil erosion, the quantity and quality of freshwater resources, and nutrient retention and cycling. Here, we focus on resource-dependent communities on the vast rangelands of the Tibetan Plateau region of China. Through this case study, we demonstrate that rangeland policy can influence the sensitivity of these ecosystems to climate change and potentially alter the capacity of the resource-dependent communities on the Tibetan Plateau to adapt.

China is not an Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC). However, China's status in the international arena has been rapidly changing since the UNFCCC began 15 years ago. Today, China, the world's second largest economy, shares many characteristics with Annex I countries, including global economic clout, political power, regional and increasingly global leadership, and the highest annual greenhouse gas emissions in the world (Grumbine 2007). It also has large socioeconomic disparities between its urban, industrialized populations and its rural, resource-dependent populations. In the face of this large and growing inequality, wealthy, urban citizens of China arguably have more in common with citizens of wealthy, industrialized countries than with marginalized, resource-dependent Chinese citizens such as those who live on the Tibetan Plateau; similarly Tibetan herders have, in many respects, more in common with Saami reindeer herders than they do with many other Chinese citizens. Indeed, in considering questions of resource access and climate change adaptation, the analytically developed/developing or First/Third world divide can obscure more than it reveals (McCarthy 2005; Wainwright 2005).

Tibetan pastoralist communities have much in common with resource-dependent, indigenous communities of the industrialized countries of the Arctic, including the USA and Canada, as well as Norway, Sweden, Finland, and Russia, where rapid and significant climate change has occurred in combination with recent sociopolitical and environmental changes that increase vulnerability to climate change (Chapin et al. 2004; Ford et al. 2006, 2007; Tyler et al. 2007; Rees et al. 2008). The lesson this Tibetan Plateau case study provides is that policies that affect the status and use of natural resources will likely affect the capacity of those resources, and the communities who depend on them, to adapt to climate change. Therefore, environmental policies should be considered in the context of climate change and should complement climate adaptation policies. Moreover, policies that support resource-dependent communities' well-developed strategies for living in uncertain and variable environments will enhance adaptation of these socioecological systems to climate change.

The Tibetan Plateau

The Tibetan Plateau, situated at an average elevation of 4,500 m and covering 2.5 million km^2, is the largest and highest plateau in the world. Six of Asia's major rivers originate on the Tibetan Plateau, and approximately three billion people live on or downstream of the Plateau. The physical presence of the Tibetan Plateau influences the global climate system (Raymo and Ruddiman 1992; Kutzbach et al. 1993). Moreover, the timing and duration of the Tibetan Plateau snowpack regulates the timing and intensity of the Asian monsoon and thus has large regional climate effects (Wu and Qian 2003; Fasullo 2004; Zhao and Moore 2004; Zhang et al. 2004).

The physical environment of the Tibetan Plateau is highly variable both spatially and temporally. Approximately 85% of the Plateau landmass is above 3,000 m and 50% is above 4,500 m. However, the elevation range on the Plateau spans from less than 3,000 m to more than 8,000 m. Mean annual precipitation ranges from more than 700 mm to less than 50 mm, and mean annual temperatures range from more than 6°C to less than −10°C (Schaller 1998). Climatic conditions are also highly variable on seasonal, monthly, and daily timescales.

With the exception of its southeastern margins, the Tibetan Plateau is primarily a treeless landscape. The vegetation communities are largely determined by elevation and climate, although grazing and soils play a significant local role. Long et al. (2008) identified four major ecosystem types on the Tibetan Plateau: alpine meadow, alpine steppe, alpine desert, and alpine shrub. These vegetative communities combine to form the vast rangelands of the Tibetan Plateau, which is one of the most extensive grazing systems in the world (Miller 1990). These rangelands support Tibetan livestock and a diverse assemblage of wildlife (Schaller 1998).

Pastoralism has been the main form of subsistence for the Plateau's inhabitants for millennia, and animal husbandry is still the main source of livelihood over much of the Plateau (Miller 1999a) (Fig. 31.1). Today, grazing practices are semiresident, characterized by a winter area used as a home base and seasonal mobility to track favorable forage conditions (Long et al. 2008). Herders have a diverse mix of livestock, including sheep, goats, and yaks, with proportions varying

Fig. 31.1 Tibetan boy and girl riding a yak on the eastern region of the Tibetan Plateau

across the Plateau. Natural vegetation generally supports livestock year round, with forage availability and quality improving throughout summer, and herds primarily subsisting on senesced vegetation throughout winter. While livestock production is the base of the economy, other activities, such as the collection and trade of medicinal plants, are increasing in importance in some regions of the Plateau (Janes 1999; Law and Salick 2005; Winkler 2008).

Climate Change on the Tibetan Plateau

Several lines of evidence suggest that climate warming is already occurring on the Tibetan Plateau. This evidence includes ice core data (Thompson et al. 1993, 2000), long-term meteorological measurements (Liu and Chen 2000; Wu et al. 2007; Liu et al. 2008; You et al. 2008), glacial retreat (Yao et al. 2007), and local residents' observations of climate change on the eastern region of the Plateau (Byg and Salick 2009). Mean surface temperature has risen by up to 0.3°C every 10 years over the last 50 years (approximately three times the global warming rate), and future warming on the Plateau is predicted to be "well above the global mean" (Christensen et al. 2007). Eighty two percent of the Plateau's glaciers have retreated in the past half-century, and 10% of its permafrost has degraded in the past decade (Qui 2008). As these changes continue, or even accelerate, their effects will resonate far beyond the Plateau (Cyranoski 2005; Qui 2008).

Climate change is not only leading to warmer temperatures, but is also predicted to increase the frequency and intensity of extreme weather events. Precipitation extremes are predicted to increase, particularly in regions where positive trends in mean annual precipitation are expected (Meehl et al. 2007). The Tibetan Plateau is among the regions where increases in mean annual precipitation are predicted to occur (Christensen et al. 2007). Empirical evidence and models suggest it is very likely that extreme precipitation events will increase in the mid-latitudes, with greater increases in the frequency than in the magnitude of these events (Christensen et al. 2007). On the Tibetan Plateau, extreme weather events consist of snowstorms that cover the vegetation and prevent animals from accessing their primary food source. During the winter months, livestock tend to survive on intact, but senesced vegetation on the rangelands. Where supplementary feed is not available, livestock lose up to 30% of their body weight over winter (Miller 1998; Wu and Yan 2002). Therefore, large snowstorms that cover the vegetation for extended periods of time can cause high livestock mortality rates. Snowstorms are not a new phenomenon on the Tibetan Plateau. However, climate models predict an overall increase in winter precipitation on the Tibetan Plateau (Christensen et al. 2007), and data suggest that the frequency and intensity of snowstorms may be increasing. Folland and Karl (2001) conclude it is likely there has been a widespread increase in heavy and extreme precipitation events in the mid- and high latitudes of the Northern Hemisphere. Regionally, there is evidence for increasing spring snow accumulation over the past few decades on the Tibetan Plateau (Zhang et al. 2004; Niu et al. 2004). The observed changes in extremes are qualitatively consistent with changes in model simulations of future climate (Christensen et al. 2007).

Political-Economic Changes on the Tibetan Plateau

At the same time, dramatic political-economic changes have taken place on the Tibetan Plateau over the past 60 years, with the region's incorporation into the People's Republic of China. From the 1950s through the 1980s, pastures and livestock were collectivized and managed through communes (Goldstein and Beall 1990; Bauer 2008). Herd decollectivization to households took place in the 1980s, while pasture remained, at first, held in common. However, since China's economic reforms, the direction of policy has been toward greater marketization and privatization. Herders soon came to be seen as insufficiently market-oriented (Clarke 1987, 1998; Levine 1998, 1999). At the same time, policymakers began to be concerned about grassland degradation on the Tibetan Plateau, which, based on "tragedy of the commons" assumptions, they attributed to overgrazing and irrational management (Williams 2002; Harris 2008). Privatization, it was assumed, would be better both economically and environmentally.

This dual rationale led to the extension of the Household Responsibility System to pastoral areas, in which grassland use rights are leased to households for periods of 50 years. Implementation began in the eastern Tibetan Plateau in the mid-1990s, but is still ongoing in the Tibet Autonomous Region (TAR), where in some cases leasing has been to household groups or hamlets rather than households.

This grassland use rights policy was accompanied by further efforts at sedentarization as well as an extension of fencing. This included not only fencing of reserve pastures for the winter–spring period, but also in some places, fencing of boundaries between household groups and fencing of household winter pastures. It was believed that this suite of interventions would increase off-take rate, reduce overgrazing and thus degradation, and also encourage Tibetan herders to become more market-oriented commodity producers. However, there has been little evidence to date of improvement of range conditions. Instead, various problems have emerged with the implementation of fencing policies in different parts of the Plateau, including increased labor inputs in some areas, boundary conflicts, security concerns, problems for wildlife mobility, and greater difficulty for some herders in accessing water resources (Wu and Richard 1999; Yeh 2003; Yan et al. 2005; Yan and Wu 2005). While the overall benefits of the "enclosure movement" occurring on the Plateau thus remain in doubt, it is clear that the primary functional effect of the trend toward the fixing of particular pasture use rights to particular households, and the technology of fencing itself, has been to decrease mobility and move away from traditional systems of common property.

The assumption that traditional grazing patterns are environmentally destructive led to a new policy in 2003, tuimu huancao, or "converting pastures to grasslands." This calls for fencing off areas of purportedly degraded rangelands, some for a few months at a time, and others for 5–10 years, or even permanently. In its most dramatic form, found in the 150,000 km^2 Sanjiangyuan nature reserve in Qinghai Province, it is being implemented in conjunction with ecological migration and plans for the resettlement of 100,000 nomads to towns (Foggin 2008). In these cases, the policy represents a break from previous policy trends in calling not for a technological fix to purported degradation, but rather for a complete removal of grazing from the landscape (Yeh 2005; Harris 2008).

Tibetan Pastoral Management Strategies in a Variable Environment

Environmental, economic, and political risks have long shaped pastoral social organization and livestock management practices (McCabe 2004). Tibetan pastoralists, like their resource-dependent counterparts in other regions of the world, have a considerable body of practical knowledge about surviving in their uncertain environments, and historically practiced risk-reducing adaptive strategies (Goldstein and Beall 1990; Wu 1997; Miller 1998). Among the most important for the minimization of loss from extreme weather events or conditions are multispecies grazing, mobility (Miller 2000), reserving pasture, and networks of reciprocity. Multispecies grazing, practiced throughout most of the Plateau, maximizes use of rangeland resources because different species generally exhibit different forage and habitat preferences, and minimizes risk of livestock loss from disease or extreme weather events (Mace and Houston 1989; Mace 1990, 1993; Cincotta et al. 1992; Putman 1996; Tichit et al. 2004; Shrestha and Wegge 2008a,b). Consequently, management policies or economic incentives that favor livestock monocultures may increase herder vulnerability.

Studies in rangeland systems around the world have shown that livestock mobility is beneficial to the health of rangelands, while restriction often leads to rangeland degradation (Sneath 1998; Kerven and Alimaev 1998; Humphrey and Sneath 1999; McCabe 2004; Niamir-Fuller 2005; Bedunah et al. 2006, p. 127; Kerven et al. 2008). Mobility enables African pastoralists to opportunistically access rangeland resources when droughts occur (McCabe 2004; Niamir-Fuller 2005). Flexibility and mobility are among the most important assets European reindeer herders possess for adaptation to the challenges they face (Rees et al. 2008). Access to landscape diversity is a key contributor to resilience among resource-dependent communities in the northern regions of North America and Europe (Chapin et al. 2004). Furthermore, studies show much lower levels of rangeland degradation in Mongolia where mobile pastoralism is not restricted, compared to neighboring pastoral Russia and China, where sedentarization is promoted by the state (Sneath 1998). In Australia, agistment arrangements, where livestock are transferred between pastoral enterprises where forage shortages exist to those where forage excesses exist, foster livestock mobility and enhance pastoral success (McAllister et al. 2006). In Tibet, pastoralists report that it is constant trampling rather than grazing that is more important in driving deterioration of grassland conditions, a factor also reported as contributing to grassland degradation in Inner Asia (Humphrey and Sneath 1999); livestock movements can alleviate this stress by reducing concentrated trampling of the grasslands.

In Tibet, seasonal livestock migration and temporary migration are important strategies used by pastoralists to access superior resources and to manage natural disasters (Miller 1998, 1999a, b, 2000). Two of the most important environmental constraints that affect Tibetan herders' livelihoods are (1) severe snowstorms, especially in early winter or spring, that cover vegetation and prevent grazing, and (2) inadequate growing season soil moisture that results in insufficient vegetation. To cope with these constraints, Tibetan herders migrate individually or in groups to better vegetation conditions. Seasonal migration occurs annually, but the timing, distance, and duration vary. Temporary migration occurs in response to locally acute environmental conditions, for example, herders may move to places where they perceive there is less, or no, snow and better vegetation.

Our work suggests that rangeland policies on the Tibetan Plateau may be decreasing the capacity of that ecological and social system to adapt to climate change. The recent grazing removal policy may increase the sensitivity of Tibetan ecosystems to climate warming, which will require greater adaptation of the social and ecological system. Furthermore, the political-economic transformations documented above have changed herding and pasture management strategies that developed as means to survive in a variable and unpredictable environment.

Ecosystem Sensitivity to Climate Warming

In 1997, we initiated an experimental study to examine the separate and combined effects of warming and grazing in the northeastern Tibetan Plateau (Klein et al. 2004, 2007, 2008). This work was motivated in part by the need to investigate the controls of different factors on the structure and function of the Tibetan Plateau grassland ecosystem. We conducted this research at the Haibei research station, which is situated at latitude 37°37′N, longitude 101°12′E. We set up the experiment in a higher elevation, summer-grazed shrubland habitat and a lower elevation, winter-grazed meadow habitat. Within each habitat type, we fenced two 30×30 m areas within which we placed the experimental plots. Our treatments were simulated warming, grazing, and combined warming x grazing. We simulated warming using open top chambers (OTCs) (Fig. 31.2). The chambers mimic the greenhouse effect in that they allow transmission of shortwave radiation, but block and reradiate downwards the infrared radiation. OTCs are used by the International Tundra Experiment and are commonly employed to study the effects of climate warming on ecosystems (Marion et al. 1997; Arft et al. 1999). The OTCs consistently elevated growing season averaged mean daily air temperature at 10 cm above the soil surface by 1.0–2.0°C. We simulated the defoliation effects of grazing through selective clipping, which mimicked the grazing patterns of local livestock and had the same effects on measured plant properties (Klein et al. 2007, 2008). Additional details on the study site, the experimental design, and the microclimate effects of the treatments are documented in Klein et al. (2004, 2005, 2008).

We found that warming generally had negative effects on key vegetative properties. Warming in the absence of grazing caused a significant decrease in overall vegetative production and a decrease in overall plant diversity. These changes represent a decrease in the carrying capacity of the rangelands, a loss of potentially important species, and a potential loss in the ability of the system to respond to future perturbations. Warming also led to an expansion of the shrublands at the expense of meadow vegetation. Increasing shrubs on the landscape has implications for the system's energy balance, carbon storage, carrying capacity, and herd composition. We also examined how important ecosystem services responded to warming, specifically examining two: palatable livestock forage and medicinal plants. Palatable forages are plants that the animals prefer to graze, those that are nutritious and enhance livestock health and survival, and which thus form the basis of the entire animal husbandry system. Medicinal plants are utilized by pastoralists both for local health and as a source of income, as the domestic and international markets for Tibetan medicine are growing (Janes 1999; Law and Salick 2005). We found that warming also reduced the number of medicinal and palatable plant species, resulting in a potential warming-induced loss of ecosystem services on the Plateau.

Grazing buffered the system from the warming-induced losses of vegetative properties and ecosystem services. That is, when warming occurred in the presence

Fig. 31.2 Experimental warming plots (using open-top chambers) within the winter-grazed meadow site at the Haibei Research Station, northeastern Tibetan Plateau (latitude 37°37′N, longitude 101°12′E). Sheep are grazing in the background after a light April snowstorm. Curved, dark feature on the hill is a fence made from sod

as opposed to in the absence of grazing, there were fewer changes in vegetative characteristics and ecosystem services (Fig. 31.3). For example, by the fourth year of the experiment, warming in the absence of grazing significantly decreased total aboveground net primary production (ANPP) by 60 $g^{-2}year^{-1}$, while warming in the presence of grazing decreased total ANPP by 30 $g^{-2}year^{-1}$; furthermore, the amount of ANPP in the combined warming and grazing plots was not statistically different from that in the control plots (Klein et al. 2007). Not only did grazing mediate warming induced losses in total ANPP, it also mediated losses of overall plant diversity. For example, by the fourth year of the study, warming in the absence of grazing lead to a loss of nine species from the system; in contrast, warming in the presence of grazing had no effect on species richness (Klein et al. 2004). Thus, we found that grazing made the system less sensitive to warming. By dampening the negative impacts of warming, grazing reduced the amount of adaptation required to climate change. Current rangeland policies, which are removing grazing altogether from some regions of the Plateau, may increase the sensitivity of the system to climate warming and thus require greater adaptation to climate change in the region.

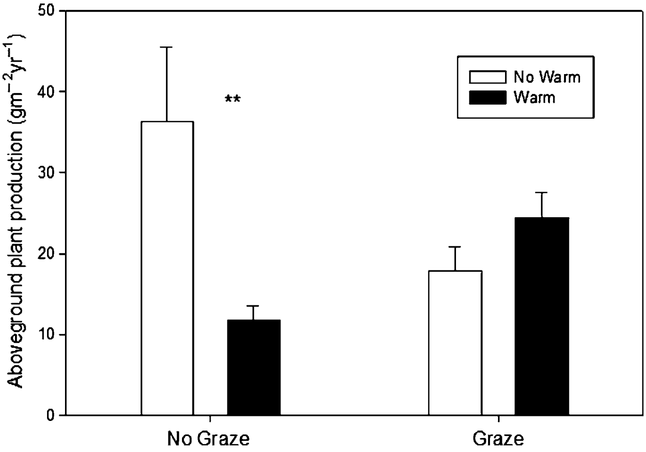

Fig. 31.3 Warming effects on the aboveground annual production of the medicinal plant *Gentiana straminea* in 2001. Warming significantly reduced the production of this medicinal plant in the non-grazed plots but had no significant effect on plant production in the grazed plots. The average production in warmed plots is represented by the *black bars*, while the average production in non-warmed plots is represented by the *white bars*. Nongrazed plots are on the *left*, while grazed plots are on the *right*. Bars represent means and standard errors. While this figure depicts results for a single species, this pattern was also observed with respect to total aboveground biomass and species richness (see Klein et al. 2004, 2007, 2008)

Adaptation to Snow Disasters

While phenomena such as drought and snow are climatic events, hunger and starvation are social ones (Sen 1981; Watts 1983; Watts and Bohle 1993). Thus, an analysis of vulnerability to snowstorms requires understanding not only physical conditions, but also political-economic processes. Miller (1998, 2000) suggests that as a result of mobility-based and other adaptive strategies, Tibetan herders did not historically experience large-scale famine following periodic drought and snowstorms. Our preliminary research shows that nevertheless, snowstorms did historically cause large-scale loss of livestock and in some cases, dramatic impoverishment. The snowstorms of 1997–1998, in which millions of livestock perished, were particularly devastating and were, in many places, the worst in living memory. The Chinese government called for emergency food relief for the herders, and in some areas such as Nagchu, implemented livestock restocking efforts for the hardest hit families.

The severity of the effects of the 1997–1998 snowstorms, including the need for emergency food aid, suggests the need to understand how Tibetan herders' vulnerability to snowstorms may be changing. As discussed above, climate models predict that extreme weather events, such as snowstorms, may become more severe and intense (Christensen et al. 2007). Furthermore, weaker livestock are more susceptible to perishing in snowstorms; thus, conditions that weaken livestock make herders more vulnerable to climate change. Our preliminary research in Nagchu, one of the hardest hit areas of the 1997–1998 storms, suggests that herders widely regard their livestock to have become weaker in recent years, due to deteriorating conditions of the rangelands. This in turn is likely to be driven in part by the effects of climate change, the mobility-reducing rangeland policies documented above, or interactions between the two (Williams 2002; Wu and Yan 2002; Yan et al. 2005; Yan and Wu 2005; Harris 2008). In addition, summer drought conditions preceding a severe snowstorm also weaken livestock, making them less likely to survive. Thus, the probable increase in frequency of all kinds of extreme weather events with climate change is also likely to act as a factor that increases herders' vulnerability.

In addition to livestock condition, the other key factor in determining livestock mortality in a severe snowstorm is ability to access foodstuff. Historically, temporary migration to pastures less covered with snow has been one of the only options available for coping with severe storms in the short term. However, the current trend toward hardened property boundaries and decreased mobility has the potential to exacerbate future vulnerability by reducing the ability to move in the short term. Decreased mobility may be offset by ongoing infrastructural improvements, such as the availability of telephones (information access) and better roads (to receive government aid and move livestock by truck), but the degree to which these can compensate for decreased flexibility remains to be seen. For example, herders may in the future have better information about good locations and even the ability to move their herds there through access to roads, but they may lack the rights or permission from other herders to graze their livestock on allocated pastures. While during the 1997–1998 events most herders were able to move and graze on other herders' pastures without being charged a fee, the ongoing reconfiguration of traditional social networks through economic reform and state development programs makes this an open question in future events. It also remains to be seen whether the government will remain flexible enough to follow the current policy, which calls for opening pastures, even those that have recently been declared permanently closed to grazing by tuimu huancao, to herders during snowstorms.

The other major option for reducing vulnerability to snowstorms would be to increase stored forage so that movement is unnecessary, even during a prolonged snowstorm. The increase in general income levels is leading to greater ability to store grain, and the government is making efforts toward hay production. However, the labor, skills, and capital inputs needed to produce adequate forage for such an event currently still fall far short of what would be required in many areas (Wu and Yan 2002). The government is also currently developing grain storage areas for distribution during snowstorms. What this indicates is an increasing trend toward relying on external aid during times of crisis, rather than traditional methods that herders could engage in themselves. In this sense, current rangeland policies may be fostering a system that is less internally resilient to extreme events that are expected to increase with climate change. Similarly, in a discussion of reindeer herders in Europe, Rees et al. (2008) assert that trucking reindeer to preferred pastures and providing artificial feed may increase herders' vulnerability to threats such as climate change, as reliance on these improvements increases herders' dependency on the state and decreases their flexibility to respond to these threats.

Conclusion

China's National Climate Change Programme suggests that its current rangeland policies constitute a "key area for adaptation to climate change" (PRC 2007). However, an examination of these current policies in their larger historical policy context suggests that they have been formulated and shaped by non-climate-related considerations, including a strong basis in tragedy of the commons assumptions about overgrazing and the benefits of private property, and the need to turn herders into commodity producers for development. Regardless of their origin, our experimental results indicate that current rangeland policies may do the opposite of what would be desirable from the perspective of adaptation to climate change. The grazing removal policy could increase the negative warming effects on the rangelands and require even greater adaptation. At the same time, the restriction on mobility through fencing and an emphasis on individual rangeland use rights limit the ability of herders to adapt to climate change.

The lesson to be learned from this case study is that policies that affect the status and use of natural resources will likely affect the capacity of those resources, and the communities who depend on them, to adapt to climate change. This is important for other resource-dependent communities such as those found in the Arctic, where mobility, resource flexibility, and strong social networks have (as in the Tibetan case) traditionally facilitated a mitigation of vulnerability, but where social, political, and biophysical changes have begun to undermine this adaptive capacity (Chapin et al. 2004; Tyler et al. 2007; Rees et al. 2008). In all cases, policymakers should take great care to develop environmental, economic, and climate change adaptation policies that are complementary. This will require significant institutional and bureaucratic coordination and cooperation, and a commitment from the top to ensure that all policies, and not only those that specifically target climate change, work toward, or at least do not contradict, the goal of climate change adaptation. Finally, policies that support the long-standing strategies developed by resource-dependent communities for living in highly variable environments will also enhance adaptation of these social and ecological systems to climate change.

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