



Cross-boundary and cross-level dynamics increase vulnerability to severe winter disasters (dzud) in Mongolia

María E. Fernández-Giménez^{a,*}, B. Batkhishig^a, B. Batbuyan^b

^a Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO 80523-1472, United States

^b Center for Nomadic Pastoralism Studies, PO Box 43, Ulaanbaatar-13, Mongolia

ARTICLE INFO

Article history:

Received 3 March 2012

Received in revised form 3 July 2012

Accepted 4 July 2012

Available online 1 August 2012

Keywords:

Pastoralists

Institutions

Governance

Resilience

Adaptive capacity

Rangelands

Drylands

ABSTRACT

Dzud is the Mongolian term for a severe winter weather disaster. With global change dzud may increase in frequency and intensity, placing livestock and livelihoods at risk. We conducted in-depth case studies of dzud impacts and responses in two mountain-steppe and two Gobi desert-steppe districts in Mongolia. We used focus groups, key informant interviews, a household survey and photovoice to document individual and community experiences with dzud and identify the factors that make some households and communities more vulnerable to dzud and others less so. We found that dzud is a complex social–ecological phenomenon and vulnerability to dzud is a function of interacting physical, biological, socio-economic and institutional factors. Vulnerability was affected by factors within and interactions between communities as well as cross-level dynamics. Communities that are well prepared for dzud at the household level may suffer disproportionate losses if exposure is increased by in-migrating livestock from other districts. Relief aid that helps prevent loss of life, suffering and impoverishment in the short-term may contribute to long-term dependence syndromes, social disparities, and lack of initiative on the part of both herders and local government. Based on our findings, we recommend that dzud policies and programs promote: (1) increased individual responsibility for disaster preparedness; (2) greater cooperation and communication on disaster planning and response among different actors within communities and across governance levels; (3) sustained and scaled out investment in building local capacity for collective action through formal herder organizations; and (4) effective cross-level institutions to manage pastoral movements and pastures.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Dzud is the Mongolian term for a winter weather disaster in which deep snow, severe cold, or other conditions render forage unavailable or inaccessible and lead to high livestock mortality. Dzud occurs regularly in Mongolia, and plays an important role in regulating livestock populations. However, dzud, especially when combined with other environmental or socio-economic stresses and changes, can have a significant impact on household well-being as well as local and national economies. Mongolia has experienced documented changes in climate in the past 60 years (Batima et al., 2005), and extreme events such as dzud are predicted to increase in frequency and magnitude with future atmospheric changes (Bayasgalan et al., 2009). Dzud has already increased in frequency since 1950 (Table 1). Therefore, understanding the effects of dzud

on herder households and communities, and identifying the strengths and limitations of existing household, community and government coping and adaptive responses to dzud is critical to developing effective strategies to adapt to climate change and manage pastoral risk related to weather disasters. Considering that rangelands account for 40–50% of Earth's terrestrial surface, are home to 40% of the world's population (Reynolds et al., 2007), and directly support the livelihoods of 100–200 million mobile pastoralists worldwide (WISP, n.d.), the lessons from Mongolia's dzud may have wider implications for managing disasters in drylands characterized by extensive livestock production systems, where mobility and reciprocity are often key strategies for sustainability (Fernandez-Gimenez and LeFebvre, 2006; Niamir-Fuller, 1998; Alimaev and Behnke, 2008; McAllister et al., 2006; Turner, 2011).

In the winter of 2009–2010, Mongolia experienced the most severe dzud since the consecutive dzud winters of 1999–2002, in which 30% of the national herd perished and thousands of households were left destitute. The 1999–2002 dzud was an important catalyst for a number of donor-led efforts to improve pasture and livestock management and risk preparedness using

* Corresponding author. Tel.: +1 970 491 0409; fax: +1 970 491 6754.

E-mail addresses: maria.fernandez-gimenez@colostate.edu (M.E. Fernández-Giménez), batkhishig.baival@yahoo.com (B. Batkhishig), b_batbuyan@yahoo.com (B. Batbuyan).

Table 1

Dzud incidence and frequency in Mongolia during the past 70 years (updated from (Reading et al., 2006)).

Year	Type of Disaster	Frequency within 20 year period	Average interval between events
1944–1945	dzud + drought	1950–1970: 3	5 years
1954–1955	dzud		
1956–1957	dzud		
1967–1968	dzud + drought	1970–1990: 2	9.3 years
1976–1977	dzud		
1986–1987	dzud		
1993–1994	dzud	1990–2010: 6	2.8 years
1996–1997	dzud		
1999–2000	dzud + drought		
2000–2001	dzud + drought		
2001–2002	dzud + drought		
2009–2010	dzud + drought		

community-based approaches. In the 2009–2010 dzud, about 8.5 million livestock died, approximately 20% of the country's livestock population, affecting 769,000 people or 28% of Mongolia's human population (ReliefWeb, 2010). According to the Red Cross, 220,000 herding households were affected of which 44,000 households lost all of their livestock and 164,000 lost more than half their herd (IFRC, 2010). This study aims to learn from this disaster to identify vulnerabilities, inform and improve response measures, and suggest strategies for strengthening community resilience to future dzud.

Mongolians identify at least six types of dzud (Begzsuren et al., 2003; Siurua and Swift, 2002; Tachiiri et al., 2008) based on the nature of the disaster. In a white dzud, deep snow covers grass; black dzud refers to freezing temperatures and lack of snow and forage; and a hoofed dzud occurs when many livestock converge in a location, and the combination of trampling and heavy grazing eliminates forage. Most of the scant research on dzud focuses on its meteorological characteristics and impacts on livestock populations (Begzsuren et al., 2003; Siurua and Swift, 2002; Tachiiri et al., 2008). These studies suggest that deep snow or the combination of deep snow and poor forage conditions in the preceding summer best explain how dzud kills livestock. Low temperatures alone do not explain livestock mortality (Begzsuren et al., 2003), but when deep snow and cold occur together, dzud is most severe (Morinaga et al., 2003).

Few studies (Mearns, 2004; NSO and World Bank, 2001; Siurua and Swift, 2002; Templer et al., 1993; Murphy, 2011) have investigated how dzud affects herder households and communities, how herders individually and collectively understand and respond to dzud, and the role that local governments play in dzud preparation and response. Past research indicates that dzud has a disproportionately negative impact on poor households, and that informal mutual assistance through social networks is an important coping strategy (Templer et al., 1993), even as such networks are weakened by economic reforms (Mearns, 2004; Siurua and Swift, 2002; Murphy, 2011) or because all households in a given area are affected (collateral risk) (Templer et al., 1993). Sternberg (2010) identified a number of weaknesses in the Government of Mongolia's capacity to respond to dzud, including lack of communication and coordination among government ministries and relevant scientific institutes, differences in knowledge and capacity between rural and urban areas, and the challenge of communication and data sharing with remote rural sites.

This study aimed to fill the gaps in knowledge about the impact of dzud on households and communities, and the role of local-level formal and informal institutions in mitigating or responding to dzud, by conducting in-depth case studies of four communities' responses to the 2009–2010 dzud. The specific objectives of this study were to assess herder household and community vulnerability, adaptive capacity, and short-term recovery from the dzud of 2009–2010. We aimed to identify factors associated with household and community

vulnerability, adaptive capacity and resilience to dzud, and to make recommendations for rangeland and pastoral development policy based on these insights. The paper is organized as follows. After providing the conceptual background for this study (1), we introduce the study sites and methods (2), present a brief narrative summary of each case (3) followed by a cross-case analysis of vulnerability supported by our qualitative and quantitative results (4). We then report on the findings related to the impacts emergency aid (5), and herders' plans for the future and evidence of adaptation (6). The discussion (7) highlights 3 emergent lessons from this analysis and the conclusion (8) makes policy recommendations based on these lessons.

1.1. Vulnerability, resilience and adaptive capacity in pastoral systems

Vulnerability is defined as susceptibility to damage or harm (Adger, 2006; Agrawal, 2010; Eakin and Luers, 2006; Turner et al., 2003), and consists of three components: exposure to harm, sensitivity to harm, and adaptive capacity. Adaptive capacity is the ability to respond constructively to variability and change (Chapin et al., 2009), including natural disasters and novel disturbances, and is associated with the ability to learn, experiment and innovate (Armitage, 2007). Poverty, vulnerability and climate change are thought to be closely related, because poor populations often are most sensitive to harm, have less capacity to adapt, and may be differentially exposed to stressors (Mearns and Norton, 2010). Pastoralists make up a large proportion of the rural population in grasslands of Mongolia, which will likely be affected significantly by changing climate (Angerer et al., 2008). Thus, pastoralists' exposure to the potential impacts of climate change is high. Further, people who depend directly on forage and water for their livelihoods are more vulnerable to the impacts of climate change than those whose livelihoods are only indirectly linked to grasslands. Therefore, pastoral populations are also likely to be sensitive to climate change impacts. Pastoralists that experience high levels of poverty, including those in Mongolia, also have greater sensitivity, and potentially less capacity to adapt to these changes.

Resilience is the amount of change a system can absorb without altering its essential structure and function (Walker and Salt, 2006). Recognizing that change is constant and pervasive, resilience theorists propose that learning to live with change is a more successful strategy than trying to control or limit it (Berkes et al., 2003; Holling and Meffe, 1996). Natural disturbances such as dzud, drought, fire or floods are important to the function of many ecosystems, and are part of their natural variability. Many pastoral societies have developed strategies to deal with the inherent variability in their biophysical and social environments, including (1) making use of diverse species, habitats and livelihood strategies; (2) mobility of herds and households in space and time; (3) flexibility in mobility patterns, social organization and livelihood strategies

employed; (4) de facto or intentional grazing reserves; and (5) institutions of reciprocity and exchange (Fernández-Giménez and LeFebvre, 2006; Fernández-Giménez and Swift, 2003). These strategies closely resemble those that many different types of local communities employ in response to a variable and changing environment (Agrawal, 2010). Of particular importance in our case studies is a specific type of pastoral movement used in Mongolia called *otor*. *Otor* is a rapid and sometimes long-distance movement of herders and a portion of the pastoral household undertaken to fatten animals in the fall, to seek better pastures in a drought or to flee bad weather and poor forage in a *dzud*. *Otor* movements undertaken during disasters frequently take herders beyond of the borders of their home administrative district (*soum*) and depend heavily on informal relationships of reciprocity among herders in neighboring *soum*, although local governments are also sometimes involved in negotiating access.

Gunderson and Holling (2002) proposed that ecosystems and by extension, social–ecological systems, undergo an ongoing adaptive cycle of change, whereby a system grows, conserves, collapses and reorganizes time and again. Adaptive capacity, the ability to learn, adapt and reorganize as a system moves through this cycle repeatedly over time, is key to resilience. Robinson and Berkes (2011) point out that pastoralists' adaptation to natural variability and disturbance regimes is distinct from adaptive capacity, the ability to learn and change in response to novel disturbances. Mongolian herders are well-acquainted with *dzud* and have long drawn on their traditional knowledge and management strategies to survive and recover from it, but the combined effects of climate change, increasing *dzud* frequency, economic reforms and market volatility, and weak institutions for pasture management confront them with a novel set of interacting stressors, and raise the question of whether this system will retain its resilience or undergo an undesirable transformation due to its limited adaptive capacity (Batkishig et al., 2011). In particular, formal institutions for pasture management were weakened following the dismantling of the herding collectives after the 1992 transition to a market economy (Fernández-Giménez, 1999; Fernández-Giménez and Batbuyan, 2004; Mearns, 1996), and customary institutions for collective management of pastures have been slow to re-emerge, giving rise to concerns about an emergent tragedy of open access (Dorligsuren et al., 2011).

Analysis of system resilience requires attention to the dynamics of cross-level interactions—that is, the ways that processes and structures at one spatial or temporal level affect those at levels above and below that focal level (Peters et al., 2004). In this article, we adopt the terminology proposed by Cash et al. (2006), who distinguish between cross-scale and cross-level dynamics with “scale” referring to “the spatial, temporal, quantitative and analytical dimensions used to measure and study any phenomenon, and ‘levels’ as the units of analysis that are located at different positions on a scale.” In Mongolia, the *bag* (sub-district), *soum* (administrative district), *aimag* (province) and nation are distinct and nested territorial-administrative units that represent different levels of formal government jurisdiction and administration along the same scale. Often we cannot understand the consequences of specific events or changes by focusing at a single level. Processes that occur over long time periods and broad spatial extents often dominate those that occur faster and over smaller areas. However, sometimes dynamics at fine resolutions cascade upwards to alter broad patterns, and ultimately may alter system function (Cumming and Norberg, 2008). The resilience of complex coupled systems such as Mongolian pastoral social–ecological systems depends upon their capacity to adapt and to maintain self-regulating feedbacks within the system. In social–ecological systems, the human ability to learn and act on the basis of new information can play a key role in system adaptation and self-regulation. This is one reason why various forms

of ecological knowledge—local, traditional, and scientific—as well as environmental monitoring are critical to the resilience of these systems (Berkes et al., 2003). Social institutions (rules, norms, policies and laws) that are adaptive, flexible, locally responsive, multi-level and diverse are thought to promote resilience, in part because they provide rapid and locally attuned mechanisms to apply monitoring results to future actions (Folke et al., 2005). Successful adaptive governance institutions help maintain the resilience of desirable systems in the face of change, but also recognize the opportunity and need to transform systems in the face of crisis—to create new, more desirable systems.

The development of theory about resilience and its application to environmental governance are recent, and the science of measuring vulnerability, resilience and adaptive capacity is also new. This paper seeks to advance the practical application of these concepts by using them to analyze the impacts of the 2009–2010 *dzud* disaster in Mongolia, and make policy recommendations for future resilience-building based on our findings.

2. Study sites and methods

2.1. Study sites

We conducted case studies of *dzud* impacts and responses in four *soum*, two in the mountain-steppe zone of Arkhangai Aimag (Ikhtamir and Undur Ulaan) and two in the desert-steppe region of Bayankhongor Aimag (Jinst and Bayantsagaan). Each pair of *soum* includes one site where donors have invested in projects to organize formal community-based rangeland management (CBRM) organizations (the Swiss Agency for Development and Cooperation (SDC)'s Green Gold Ecosystem Management Program (GGEMP) in Ikhtamir, and the United Nations Development Program (UNDP) Sustainable Grasslands Management Program (SGMP) in Jinst). This paired design enabled us to compare the preparation for, impact of and response to *dzud* in communities within each ecological zone with and without formally organized herder collective action institutions. A January 2010 UNICEF map of *soum* affected by the 2009–2010 *dzud* identified Ikhtamir and Jinst as “affected” and Undur Ulaan and Bayantsagaan as “extremely affected.” Table 2 summarizes the community characteristics of the 4 study sites.

2.2. Focus groups, interviews and photovoice

We used a suite of qualitative methods to gather data on herders' experience of and response to the *dzud*, and to understand the role and actions of local government and donor and relief aid organizations before, during and after the disaster. Fieldwork in Ikhtamir and Undur Ulaan took place in June 2010, immediately following the *dzud*, and in Jinst and Bayantsagaan in September 2010, early in the first autumn following the *dzud*. In each study site, we first interviewed local government officials (11 interviews), donor project staff (16 interviews) including CBRM programs and other projects involved in improving herder livelihoods or resource management, or providing relief aid, and interviews with leaders of formally organized herder groups (3 interviews). To document herders' experience and response to the *dzud*, we convened 1–2 focus groups at each site and facilitated a discussion of herders' experiences, *dzud* impacts, coping and adaptive responses, outside and mutual aid and assistance, collective action in response to the *dzud*, and lessons learned (91 participants in 6 focus groups, lasting 1.5–2 h each). All interviews and focus groups were audio-recorded and transcribed and transcripts were coded using an initial list of codes based on the research objectives and interview/focus group protocols. Emergent themes were identified and the transcripts were

Table 2
Characteristics of study sites.

	Mountain steppe		Desert steppe	
	Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan
Ecological Characteristics				
Ecozone	Mountain-Steppe	Mountain-Steppe	Desert-Steppe	Desert-Steppe
Area (ha)	485,000 ha	440,000 ha	531,264 ha	539,513 ha
Ave. Precipitation	342 mm		105 mm	
Standing Crop Aug. 2009	19.2 g/m ²	18.3 g/m ²	8.2 g/m ²	No data
Habitat Diversity	High	High	Moderate	Low–Moderate
Recent Environmental Changes				
	Temperature increase Precipitation decline Peak and annual streamflow declines	No data on climate change Peak and annual streamflow decline Loss of 55% of natural springs	Temperature increase No change in streamflow	No data on climate change
Human Population (2009)				
Total Population	5247	5798	2023	3401
Total Households	1415	1570	458	975
Herder Households	1073	1220	404	672
Livestock Population (sheep forage units: SFU)				
2009 (pre-dzud)	515,818	502,206	149,349	140,563
2010 (post-dzud)	393,794	415,597	100,631	91,552
%Loss Soum Level	23.7	17.2	32.6	34.8
%Loss Surveyed Households	30.7	42.9	13.7	38.9
Pre-dzud Poverty Indicators				
Soum statistics: SFU/hh	480.7	411.6	369.7	209.2
Survey: mean SFU/hh	1161.3	550.4	431.5	353.8
Survey: median SFU/hh	508	419	397	245
Donor Projects (Pasture and Risk Management-related)				
	World Bank SLP World Vision SDC GGEMP	World Bank SLP World Vision	World Bank SLP World Vision UNDP SGM	World Bank SLP World Vision
Formal Community-based Rangeland Management Institutions				
Yes		No	Yes	No
SDC			UNDP SGM	
GGEMP			Herder Groups (6)	
Pasture User Groups (13)				

re-coded in order to be sure that these themes were captured in the coding. Coded passages were arranged into tables to facilitate comparison within and across the case study sites and the results were synthesized and summarized in case study reports for each site. Throughout this process, we were vigilant for discrepant data that contradicted the prevailing trend in the coded passages.

We deepened our understanding of dzud through photovoice, a participatory research method that empowers community members to describe and analyze their world with images and words they create (Wang and Burris, 1997). Five herders in Ikhtamir and two in Jinst were given cameras for 5–7 days and asked to take pictures related to the dzud. At the end of the photography period, the volunteers reconvened and each photographer selected 5 images to print and discuss with the group. This method helped the researchers to understand the dzud through herders' eyes, and stimulated additional discussion among herders about appropriate measures for dzud preparedness and response, and lessons learned from the dzud.

2.3. Household survey

A short household survey was used to assess quantitatively dzud preparedness, impacts and responses at the household level. A stratified random sample of households in each of the study sites was surveyed. Stratification was based on participatory wealth ranking carried out with 3–4 informants in each study location.

Ninety-four households were surveyed in total, 32 in Ikhtamir, 18 in Undur Ulaan, 28 in Jinst and 16 in Bayantsagaan. More households were surveyed in the soums with CBRM projects in order to capture variation between CBRM member and non-member households within the same soum. Data were collected by four trained enumerators using a face-to-face closed-end questionnaire. The questionnaire consisted of 6 sections: (1) household demographics, (2) livestock inventory pre- and post-dzud, (3) pre-dzud conditions and winter preparations, (4) dzud impacts and responses, (5) aid received and perceived effectiveness, and (6) future plans. To assess the relationship between social capital and household vulnerability, we relied on survey data previously collected from the same households in 2009. In the 2009 survey, we used two social capital indices, one measuring trust and reciprocity (cognitive social capital) and the other respondents' perceptions of the quality of and their access to local leaders, community organizations, knowledgeable resource people, and local government (structural social capital). We also assessed communication networks, an index of access to 8 different types of information (livestock marketing, health, nutrition, pasture management, monitoring, risk management, environmental protection and legal advice) and information diversity, an index of access to 10 different information sources (radio, TV, newspapers, brochures, technical experts, government officials, veterinarians, herders in my camp, visiting herders, local government meetings). Data were analyzed using SPSS 17.

To identify factors that influenced vulnerability to dzud losses, we used the percent of the 2009 herd lost in the dzud calculated in Sheep Forage Units (SFU) as the vulnerability indicator and dependent variable. One sheep is equal to 1 SFU, a cow 5 SFU, camel 6 SFU, horse 7 SFU and goat 0.9 SFU. For binary explanatory variables, we conducted Student's *t*-tests comparing the percent of herd lost for households that did and did not undertake each dzud preparation or response method. We used multiple regression to assess the relationship between percent of herd lost and continuous explanatory variables, such as mobility (total and average distance moved in the 12 months prior to the dzud, number of moves, number of different campsites). Treating the soum as a blocking variable, we used ANOVA to assess whether percent herd losses varied among the 3 wealth groups, as determined by the participatory wealth ranking used to stratify our sample. Due to the small sample size, we considered differences significant at a *p*-value of 0.10.

2.4. Construction of case studies and cross-case analysis

Qualitative and quantitative data were combined to construct detailed case studies for each of the study sites. The full case studies and supporting evidence are available in (Fernández-Giménez et al., 2012). We distilled from these in-depth case analyses brief narrative summaries for each case that profile the dzud impacts and responses in each community and highlight the major lessons learned from each case study (3.1–3.4 below). We then used both qualitative and quantitative approaches to compare and contrast vulnerability and adaptive capacity indicators across the 4 sites and among households to identify factors associated with household and community-level exposure, sensitivity and adaptive capacity.

3. Case summaries

3.1. Ikhtamir

The two Ikhtamir bag (sub-districts) varied in their preparedness for winter due to variation in resource distribution and pasture conditions within the soum, but overall Ikhtamir herders had adequate stored hay and standing reserve pasture. Preparations for winter were enhanced by the presence of formally organized pasture user groups (PUGs), formed with assistance from the SDC GGEMP, which helped organize herders to make hay and encouraged them to go on fall otor. Exposure to extreme cold was high and to snow variable, and vulnerability was significantly increased by thousands of otor livestock that migrated into the soum from other districts, bringing on a “hoofed dzud,” and leading to high livestock losses in areas where otor herds concentrated. During the disaster sensitivity to dzud was increased by herders' lack of knowledge about how to use supplemental feed, and by poorly prepared winter shelters and bedding grounds that failed to protect animals against the cold. There was little evidence of informal mutual assistance during the dzud and the PUGs did not play a strong role in helping herders cope during the disaster, although all herders received relief aid from Green Gold (as well as other agencies). After the dzud, PUGs and the umbrella Association of PUGs (APUG) were important in helping herders reflect on the lessons learned from the dzud, and in facilitating collective decision-making to improve pasture management (e.g. passing a resolution in Khan Undur bag that all herders move to Khanuu River in summer 2010 to allow Ikhtamir River pastures to rest). The local soum government in Ikhtamir did not show much initiative before or during the dzud, officials complained that they had no legal means to address the disaster created by incoming otor herders, and herders remarked that soum officials did not visit

them during the dzud. Some herders and local donor staff voiced concern about relief aid and how it was distributed, expressing that targeting poor households was unfair to herders who worked hard to prepare for winter and save their animals, and created a perverse incentive for households to become strategically poor in order to live off of aid. *A main lesson from Ikhtamir is that even communities and households that are relatively well prepared in terms of animal condition, stored hay and grazing reserves, can be extremely vulnerable if institutional arrangements are not in place to effectively manage cross-boundary mobility of otor herders.*

3.2. Undur Ulaan

In Undur Ulaan the combined effects of drought and insufficient water sources made it difficult for herders to fatten animals or store adequate hay. Few herders did fall otor. The cold was extreme and snow deep in places, but our study site within Undur Ulaan did not experience a hoofed dzud. Undur Ulaan herders failed to prepare rigorously for winter and local government did little to guide or encourage them. In addition to lacking hay stores, few households prepared hand fodder or set aside reserved winter or spring pastures. Due to inadequate preparations, Undur Ulaan herders were vulnerable to the impacts of the dzud and experienced significant herd losses. Herders in Dongoi bag engaged in new (to them) forms of cooperation in order to overcome the dzud and prevent worse losses. Neighboring khot ail (herding camps composed of several households) pooled their animals and cooperated in taking them on otor to sheltered areas in the forest. Herders from different households shared limited reserve pastures on a rotating basis. In focus groups, herders indicated interest in continuing these neighborhood-level cooperative activities, especially to protect reserve pastures and restore springs. Undur Ulaan received similar amounts of relief aid as Ikhtamir but relied on the bag governor for distribution. Most herders did not know the source of the assistance. When we arrived in late June, we observed a large pile of undistributed feed outside of the bag governor's ger (traditional round felt dwelling). Unlike Ikhtamir, the Undur Ulaan soum government did not take advantage of the dzud as an opportunity for collective reflection and action planning with herders. However, many herders expressed a new awareness of the need to limit livestock numbers, improve animal quality and collaborate to protect reserve pastures. The newly established World Bank-supported Sustainable Livelihoods Program office in Undur Ulaan could help catalyze more organized and enduring collective action by herders in the future, if sufficient support is provided for organizational development and capacity building. *Undur Ulaan illustrates how high sensitivity to dzud due to lack of preparation, absence of organized collective action and weak government support, as well as the more chronic effects of a drying climate and disappearing water sources, led to increased vulnerability to winter disaster. The case also shows how a crisis can motivate informal cooperation, raise awareness and influence herder attitudes about future herd management, and create a “teachable moment” that could be a lever for change with appropriate interventions and support.*

3.3. Jinst

Jinst was severely affected by the 1999–2002 dzud, when 75% of the soum's herd perished. Following this disaster, Jinst was selected as a site for the UNDP's SGMP and 6 herder groups were established in the soum with the program's support. Although the program ended in 2008, most of the groups continue to function. These groups have established grazing plans and reserve pasture areas, some of them fenced. Both local government and the herder groups encourage and assist herders in preparing for winter,

especially in harvesting hay from riparian areas. The soum is also endowed with a diversity of natural habitats including a river and several natural desert springs/marshes, a small and a large mountain range that provide cover and forage diversity, and several large but poorly-watered expanses of steppe that serve as de facto forage reserves. The forage and animal conditions in Jinst in the summer and fall preceding the dzud, though below average, were not severely deficient. In sum, Jinst's sensitivity to dzud was low due to ample storage on the hoof, in hay reserves, and in reserve pastures, as well as other preparations. Jinst's exposure to the weather-induced dzud was also low, as the temperatures were not as extreme as in other locations. However, Jinst was exposed to a "hoofed dzud" due to thousands of incoming otor livestock from other soum. During the dzud both local government and herders were proactive. The government directed otor herders to use the de facto reserves and organized the spring sale of thin animals to China. Herder groups responded in a variety of ways to support their members and herders demonstrated higher levels of informal mutual assistance given and received than any of the other sites. Many herders in Jinst had livestock insurance and received payment for their losses. In sum, *Jinst is an example of a resilient system, where herders and local government learned from past dzud experiences and put their learning into action to reduce vulnerability to subsequent disasters. Jinst illustrates the potential benefits of formal collective action among herders and of the resulting increased communication and cooperation between herder organizations and local government.*

3.4. Bayantsagaan

Bayanstagaan is the most arid and least diverse of the study sites, lacking natural water sources and riparian areas that produce harvestable hay or serve as natural reserves. Bayanstagaan's mountain pastures, which once could have served as a reserve, have been depleted by continuous use in recent years. Due to the poor forage conditions and limited water supplies, herders are dispersed over a large area, the distances and limited forage makes it difficult for them to cooperate, and there are no donor projects in the soum to help organize or train herders in collective pasture management. In addition, herds from even more remote and dry soum to the west and south make otor movements to Bayantsagaan putting further pressure on the limited pastures. Due to the

inherently unproductive pasture conditions coupled with the dry summer preceding the dzud, Bayantsagaan herds were in poor condition going into the winter and herders had stored almost no hay. Winter conditions were more extreme than in Jinst and livestock losses were correspondingly higher. Bayanstagaan's local government was proactive before, during and after the dzud, and the actions of local leaders likely helped prevent a worse outcome from this natural disaster. Prior to winter the local government developed a disaster plan and issued guidelines for winter preparations to all herders. As part of this edict, local government strongly encouraged herders to sell off livestock in the fall before the weather worsened. Anticipating the potential for dzud, the government also negotiated in advance otor agreements for Bayanstagaan herders with soum as far away as Tuv aimag (600 km distant), and made arrangements with suppliers for supplemental feed and fodder. During the dzud, the government coordinated effectively with relief aid organizations in the distribution of assistance to herders, who expressed satisfaction with the government's attention. Bayanstagaan herders had a high rate of livestock insurance coverage, which helped mitigate losses somewhat. Many herders who were significantly affected by dzud losses planned to migrate to other soum or cities, at least temporarily, and a large proportion of households expected that someone from their family would engage in mining to earn extra income. *The Bayanstagaan case illustrates vulnerability due to the combination of inherently limited natural assets and absence of informal or formal collective action to manage pastures. Bayantsagaan's local government set an example of leadership, pro-active planning, and effective coordination and communication during a disaster that other soum can learn from.*

4. Vulnerability analysis: a cross-case comparison

Exposure to dzud is a function of local and regional variations in temperature, snow depth, pre-existing forage conditions, and changes in forage availability during dzud due to high livestock numbers (hoofed dzud), often caused by an influx of otor herders from other areas. In addition, local geography influences both exposure and sensitivity to the dzud, because some sites offer more cover and protection from storms, are endowed with natural forage reserves, or are less remote from markets and easier to reach for the distribution of aid.

Table 3

Summary of pre-dzud conditions, preparation and responses by study site. Data are from the household survey and indicate the percent of surveyed households that carried out the stated practice unless otherwise indicated.

	Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan
Pre-Dzud Conditions (Herders' perceptions)				
% of herders who perceived pasture as worse than usual	84.4	83.3	78.6	93.8
% herders who perceived animal conditions as worse than usual	65.6	61.1	42.9	75.0
Winter Preparations 2009				
Hay cut (tons) ^a	1.5 (.3)	1.4 (.2)	1.7 (.6)	.1 (.1)
Hand fodder (%)	56.3	27.8	39.3	56.3
Fall otor (%)	81.3	33.3	75.0	62.5
Reserved spring pastures (%)	48.4	11.1	30.4	36.4
Reserve dzud pastures (%)	33.3	19.4	25.0	25.0
Responses to Dzud				
Winter otor (%)	48.4	50	28.6	43.8
Fed stored hay (%)	87.1	94.4	71.4	31.3
Fed hand fodder (%)	58.1	27.8	35.7	56.3
Fed purchased fodder (%)	100	94.4	100	100
Impact of Dzud				
% of herd lost (SFU) ^a	30.7 (3.34)	42.9 (6.7)	13.7 (2.2)	38.9 (5.9)
Species most affected (total losses in SFU) ^a	Cattle 102.3 (23.3)	Cattle 74.1 (15.6)	Goats 41.2 (10.7)	Goats 66.3 (14.7)
Species most affected (percentage loss in SFU) ^a	Cattle 41.3 (3.1)	Cattle 61.6 (12.5)	Cattle 47.2 (15.5)	Sheep 43.0 (7.3)

^a Data are mean (standard error).

Table 4

Dzud characteristics in the 4 study sites.

	Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan
Dzud Weather	28 snowfalls Ave winter temp. in 2009–2010 significantly lower than long-term ave.	33 snowfalls Jan 3–6 –40 °C	5th coldest winter in last 48 years Heavy late spring snow (April)	Freezing weather, little snow
Dzud Type	White dzud Hoofed dzud	White dzud	Hoofed dzud White dzud	Black dzud
Incoming Otor Herds	Est. 20,000 otor animals in Bogat bag alone	Est. 67,000 otor animals	Est. 56,800 otor animals, including 10,800 horses	Received some otor herds (no specific numbers)
Outgoing Otor Herds		from other soum		77 households with 40,000 head sent to 10 other soum in 3 aimag

Forage conditions preceding the dzud were perceived as poor in all sites except Jinst (Table 3). Three of the four study sites experienced extremely cold temperatures and some locations within the Arkhangai mountain-steppe sites also had significant snow cover (Table 4). Incoming otor herders from other soum critically increased the exposure of several of the sites to “hoofed dzud,” and significantly increased vulnerability, especially in Ikhtamir and Jinst (Table 4). Sites that were most exposed were those that experienced combined deep snows, frigid temperatures, and onslaught of incoming herds from other districts (Table 4). Overall, Jinst was least exposed and Undur Ulaan and Ikhtamir were most exposed in this dzud.

Sensitivity to dzud at the household level was driven by (1) animal condition (weight gain and fat storage) going into the winter, which in turn was a function of pasture conditions and herd management during the preceding summer and fall, (2) the availability and use of forage and hay reserves, especially during the spring, and adequate shelter and cover, and (3) the household's herd size.

Households whose herds went on fall otor to fatten animals had significantly lower losses than those that did not across all study sites (Table 5). We inferred that fall otor enabled the animals in these households to consolidate fat reserves sufficient to help them survive the extreme cold and food deprivation later in the winter and spring. Similarly, households that had reserved spring pasture areas survived the dzud with fewer losses (Table 5). Most households harvested some hay or prepared “hand fodder” and all households purchased some type of feed during the dzud, most commonly bran and concentrate pellets. Households that fed hay lost a smaller proportion of their herds, when the differences between the ecological zones were accounted for ($F = 3.423$, $df = 1$, $p = 0.068$). The effectiveness of feeding hand fodder may be limited due to the small quantities prepared.

Interviews suggested that many inexperienced herders did not know how to prepare and feed bran, the most common purchased feed, which may have limited the effectiveness of this strategy. According to interviews, many herders did not adequately weather-proof their winter shelters, so animals were not

well-protected from the temperature extremes. Thus inexperience and lack of knowledge increased household sensitivity to dzud.

Finally, a household's herd size also determined vulnerability. Poor households lost a significantly higher proportion of their livestock compared to mid-level and wealthy herders (Table 5). The loss of livestock impacts both the household's income earning potential and household consumption behavior which, in turn, may affect the nutritional status of household members, especially children and women, due to reduced dairy and protein intake. Loss of livestock also affects a household's ability to complete cultural and social obligations that call for exchange of animals or animal products. In addition to bringing shame on a household that is unable to offer traditional dairy products to visitors, a basic tenet of rural Mongolian culture, the inability to provide relatives in settlements or cities with meat or other products could erode the strength of these extra-local social networks, which are often critical to the survival of households during a disaster (Siurua and Swift, 2002; Templer et al., 1993). The photovoice component of our project highlighted these consequences from herders' perspectives (Figs. 1 and 2). Overall, household sensitivity was highest in Undur Ulaan and Bayanstagaan, where forage and animal conditions were worse going into the dzud, and where herders had less stored hay and limited access to reserve pastures.

At the community level, sensitivity was affected by the natural features of each soum, as well as institutional factors such as the effectiveness of local government and presence of formal collective action organizations. Soum endowed with richer pastures, natural hay-cutting areas, de facto grazing reserves and greater habitat diversity had more natural forage reserves and protected areas where herds could seek cover from the weather. Sites with proactive local governments (Jinst and Bayantsagaan) and formal

Table 5

Effect of wealth and winter preparation methods on percent of herd lost in the dzud (calculated in sheep forage units). For the comparison among wealth groups, soum was treated as a blocking factor. For all other variables, comparisons were across all soums.

	Percent of Household Herd Lost ^a			df	F	P
	Wealthy	Middle	Poor			
Wealth Group	25.5 (4.4)	29.7 (3.3)	39.2 (3.7)	2	3.296	0.043
	Yes	No		Df	t	P
Fall Otor	26.1 (2.8)	35.4 (4.2)		89	1.884	0.063
Reserved Spring Pasture	21.6 (3.8)	34.2 (3.3)		78	2.364	0.021
Reserved Dzud Pasture	24.2 (5.7)	30.2 (2.6)		88	.944	0.348

^a Mean (standard error).



Fig. 1. “The impact of dzud can be described in terms of the loss of one bucket and one cooking pot of milk.” Photographer and caption-writer: Mr. Amarsanaa, Ikhtamir Soum.



Fig. 2. “Who will herd the livestock? The reason why we have a lack of milk and yogurt is because of a loss of animals this year.” This photographer further explained that the children in the photograph include both herders’ children and their town-dwelling cousins who typically come to the countryside in the summer in part to consume the fresh and healthful dairy products. However, in summer 2010, due to high livestock mortality in the dzud, there was little dairy food to spare for guests. Photographer and caption-writer: Mr. Buyankhishig, Ikhtamir Soum.

community-based rangeland management organizations (Jinst and Ikhtamir) generally had lower sensitivity to dzud because they were better prepared for winter and pastures were better managed. In Bayantsagaan, the soum government actively encouraged herders to prepare well for winter, facilitated fall sale of livestock, negotiated otor agreements in advance of winter to send 77 Bayantsagaan households and 40,000 head of stock to other soum in 3 aimags, and effectively coordinated emergency aid during the dzud. In Jinst the local government encouraged winter preparations and facilitated spring sale of thin animals to China. In Ikhtamir and Jinst, formal herder organizations played an important role in organizing herders to cut and store hay and prepare for winter. Undur Ulaan had the weakest government and community leadership in preparing for and responding to the dzud.

At the community level, institutional factors significantly affected sensitivity. Specifically, soum with a large number of incoming otor herders had difficulty managing these herds in a way that limited the exposure of local households to the resulting “hoofed dzud.” Interviews with herders and local officials in the study sites highlight these institutional weaknesses, as illustrated by the following interview excerpts.

“We can’t do anything when otor herders come. It is not allowed to banish otor herders. When they claim our pasture is better and has less snow and try to save their few remaining livestock, it is very hard to say “no.” [Ikhtamir herder]

“Last winter around 20 households with nearly 15,000–16,000 animals from Bayanstagaan, Shinejinst, and Bayan-Undor soum entered into our grazing territory in the Bogd Mountain area for otor. The high concentration of animals around wells caused water shortages in winter pasture areas. Therefore, in conditions of not much snow, migration of animals from neighboring soum caused a so-called “hoofed dzud.” [Jinst herder]

Coping and adaptive capacities were influenced by herder knowledge and experience with dzud, effective collective action and government leadership in response to the dzud, and informal local and extra-local social networks. Jinst herders had not forgotten the lessons learned from severe impacts of the 1999–2002 dzud, and

a decade later, these lessons appear to have influenced their preparations for and ability to respond during the 2009–2010 disaster. Jinst also demonstrated strong collective action both before and during the dzud, facilitated by formal herders groups established under the UNDP SGMP, which continue to function effectively. In Ikhtamir the PUGs helped organize winter preparations, and were also important in helping herders to distill lessons learned from the dzud and inspiring post-dzud collective action to improve pasture use. However, the PUGs did not play a large role in helping herders to cope during the dzud. Although Undur Ulaan herders had less experience with formal collective action, they demonstrated small-scale spontaneous collective action during the dzud which focus groups indicated might carry over into future pasture management activities. In Bayantsagaan, formal and informal collective action among herders was weak, but the local government demonstrated initiative and innovation in encouraging herders to sell off livestock early in the winter and negotiating otor agreements with other soums. In Jinst, local government also took action to facilitate sale of thin livestock during the spring to Chinese buyers, so that herders could obtain some financial return for animals that might otherwise die.

Based on our 2009 household surveys, we found that households in Jinst had more extensive communication networks ($F = 4.756$, $df = 3$, $p = 0.004$) and access to more information sources ($F = 6.558$, $df = 3$, $p = 0.001$), than herders in Ikhtamir and Undur Ulaan, and both Jinst and Bayanstagaan had greater cognitive social capital than Ikhtamir ($F = 3.379$, $df = 3$, $p = 0.022$). There were no differences in these variables between members and non-members of formal herder organizations ($p > 0.5$ for all), and no significant impacts on percent of herd lost ($R^2 = .05$, $p = 0.365$). Qualitative data from focus groups suggest that mutual assistance among neighbors and kin within the soum was highest in Jinst and Undur Ulaan, and weaker in Ikhtamir and Bayantsagaan. In Jinst families from one of the herder groups collaborated in forming a small sewing business in the soum center. During the dzud they split their households, sending women and children to the soum center, where the women could work in the business while caring for the school children, and the men remained in the

countryside with the herds. In Undur Ulaan, herders from different camps who had not actively cooperated in the past pooled labor to care for herds and arranged rotating access to sheltered reserve pastures among multiple households. In Bayanstagaan, scarcity of forage and large distances makes cooperation among households and herding camps difficult. Across all sites, however, assistance between households was not common. This finding supports previous research about mutual assistance during dzud by Siurua and Swift (2002). Assistance from kin and friends outside of the soum was more common, especially formally organized support from soum “Homeland Associations” in Mongolia’s capital Ulaanbaatar, and the aimag centers (see Section 6).

Overall, Undur Ulaan appears to be the most vulnerable of the four case study sites. Despite some examples of endogenous collective action during the dzud, the lack of preparedness before (high sensitivity) and ineffective government response (low adaptive capacity) during the dzud led to high losses. In Bayanstagaan, although exposure and sensitivity were high, local government leadership before and during the dzud helped to mitigate what could have been even worse losses. Ikhtamir was moderately well-prepared for the dzud, but the incoming otor herders created a hoofed dzud (increasing exposure) and significantly increased vulnerability. Jinst was least vulnerable, in part because weather conditions were less severe both in the preceding summer and during the dzud (low climate exposure), and in part because of good preparation (low sensitivity) and strong coping and adaptive mechanisms (high adaptive capacity), due to a more effective local government and strong formal institutions for collective action among herders. However, some Jinst households suffered significant losses due to the large number of incoming otor herders and livestock from other soum (high use exposure).

5. Impacts of emergency aid and donor assistance

An important question for government, aid and donor organizations is how to provide assistance that will help to reduce vulnerability to a disaster such as dzud. We attempted to understand the role of aid and donor organizations in preparing herders for dzud and the effectiveness of emergency aid provided during the dzud. Sections 4 and 5 described the role of donor-sponsored formal community-based rangeland management organizations in helping Jinst and Ikhtamir herders prepare for,

respond to and learn from dzud. Here we discuss the role of emergency aid and assistance in mitigating the impacts of dzud on households.

During the dzud each of the study sites received assistance from 8 to 13 organizations or agencies external to the soum (Table 6). Some assistance was distributed to all households while other aid was targeted based on specific criteria. Aid that was evenly dispersed across all households often was too small to make an impact on individual households. On the other hand, aid that was targeted to specific households raised herders’ concerns about the criteria for and consequences of targeted distribution.

Table 6 summarizes sources and type of emergency aid in each study soum. The aid sources listed for each soum are based on the combined responses from household surveys and interviews with soum officials.

Three main concerns about emergency aid distribution surfaced in our interviews and focus groups: (1) equity and transparency in distribution of targeted aid, (2) lack of coordination between local government and different aid and donor organizations in targeting and delivering aid, and (3) perverse incentives and perpetuation of aid dependency.

As Table 6 illustrates, most food and clothing aid was targeted to specific households that were designated as most needy. In most instances, the soum governor provided a list of households that were determined to be in greatest need of assistance. In some cases, aid was transferred directly to the soum or bag to distribute. In others, staff of the donor organization used the government list as a starting point and then evaluated the households themselves. Some organizations, like World Vision, openly displayed the list of aid recipients and clearly stated the objective criteria used to select them. Nevertheless, local officials in some study sites received many complaints about how aid was distributed. In focus groups, herders differed in their views about how assistance should be distributed. Some believed it was important that aid be distributed evenly across all households so that everyone receives the same amount. Others felt that this approach diluted aid so that the amount received by each household is not enough to make an impact. As one Undur Ulaan herder said, “One sack of fodder will not feed 500 sheep.”

The different methods of aid delivery also were a source of frustration for herders and local officials in some sites. Although herders appreciated all aid, most assistance did not come at the time it was needed and often it was the wrong type of aid. Some aid

Table 6
Sources and type of emergency aid in each study soum. The aid sources listed for each soum are based on the combined responses from household surveys and interviews with soum officials.

Organization	Type of Aid	Targeted	Soum			
			Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan
National Government	Fodder, food, restocking	Yes	X	X	X	X
Soum Government	Fodder, food	No	X	X	X	X
Red Cross	Food, medicine, clothing	Yes	X		X	X
Adventist Development and Relief Agency (ADRA)	Food	Yes	X		X	
World Vision	Fodder, food, clothing	Yes	X	X	X	X
World Bank Sustainable Livelihoods Program	Fodder, food, medicine	Yes	X	X	X	X
Asian Development Bank	Cash	Yes	X			X
SDC Green Gold	Cash	No	X			
Vet Net	Medicine	No data	X			X
Veterinarians without Borders	Fodder, food	Yes	X			
UNDP	Fodder, food	Yes				X
French	Food	Yes	X			
Japanese Government	Fodder, food	No data		X		
National Parliament Member(s)	Fodder	No		X	X	X
Aimag Parliament Member(s)	Fodder	No data			X	
Erdenet Factory	Fodder, food	No	X	X	X	
Homeland Associations	Fodder, medicine, other	No data	X	X	X	X
TOTAL No. of Aid Sources			13	8	10	10

was delivered to households by agencies and other aid was deposited in central locations for herders to retrieve. Aid delivered to households often did not arrive in time and not all herders had access to transportation to pick up food and fodder supplies from a central distribution point. One of the most effective delivery networks was observed in Jinst, where aid organizations made use of existing herder groups as a delivery mechanism.

Both herders and officials in some soum expressed concern about increasing dependence of herders on external assistance, leading to perverse incentives and strategic behavior. The following herder focus group excerpts from Ikhtamir illustrate these views. Herders in Undur Ulaan made similar statements.

“Nowadays herders have become less active and this is wrong. If we continue to have a policy that ‘since he is poor we need to help him,’ then we will never reduce poverty. For some herders assistance has caused them to be lazy. So, this is the negative side of assistance. When help comes it has always been distributed among the poor herders. This makes them less active. Animals [herds] do not grow by themselves, they need care and hard work. And nobody admits that. We work very hard. And when you see that the government gives help to those people who say that they lost animals and have nothing, it makes herders more and more lazy.”

“The help makes herders less active and in the end, on top of laziness, leads to poverty.”

Staff of one donor program in Ikhtamir expressed similar concerns:

“Too much aid has the opposite effect. People become dependent on aid. People are not pro-active. They may even become poor on purpose in order to qualify for aid. We should talk directly to herders, not just rely on some other data [to select aid recipients]. We should visit them and see their conditions first hand.”

As did a soum government official:

“I want to change the dependency mentality of herders. People have an understanding of aid to benefit them and complain if they are left out of such assistance. They have got the idea to live on aid.”

6. After the dzud: plans for recovery and evidence of adaptation

Following the dzud, herder households had several options for livelihoods and residence. Livelihood options included continuing to rely solely or primarily on livestock for income, seeking supplementary income while continuing to herd livestock, or leaving the herding sector temporarily or permanently to pursue alternative livelihoods. To rebuild their herds, they could purchase livestock, wait for herds to rebuild at a natural reproductive rate, or choose to herd fewer livestock in the future. Some households that

lost all or a large portion of their herds elected to move permanently or temporarily to the soum center, aimag center or the capital city, Ulaanbaatar (Table 7). About a third of the households in the most affected sites (Undur Ulaan and Bayantsagaan) planned to restock by purchasing livestock, while the majority households in Ikhtamir and Jinst were content to allow herds to rebuild at their natural rate. Roughly one third of the surveyed households in Jinst and Bayantsagaan had purchased index-based livestock insurance prior to the winter of 2009–2010. Almost all of the surveyed herders in those soum planned to insure their livestock in 2010. Insurance was not yet widely available in Ikhtamir and Undur Ulaan and few herds were insured in 2009, but about two thirds of survey respondents planned to purchase insurance in 2010 if it was available. A sizeable minority of households in all sites did not have plans to rebuild their herds, choosing the “other” category. Many of these respondents volunteered that they planned to focus in the future on improving livestock quality, by improving selective breeding and nutrition, rather than rebuilding herd size. Focus group discussions in all sites emphasized herders’ growing awareness of the need to reduce herd sizes and increase animal quality instead, as illustrated by the following excerpts from the focus groups:

“We ought to keep livestock numbers under certain limits.” [Ikhtamir]

“It is important to pay attention to the quality, not numbers.” [Ikhtamir]

“It is necessary to pay attention to improve the quality of the remaining livestock.” [Undur Ulaan]

“In the fall, it is necessary to sort the animals and slaughter when they are fat and this will keep the livestock number in balance.” [Jinst]

Although the majority of herders planned to remain in the countryside with herding as their primary livelihood, a significant minority in the most affected sites planned to move to the soum center or Ulaanbaatar. Across all soum a quarter of respondents planned to seek supplemental or alternative livelihoods. In Bayantsagaan, half of all surveyed households planned to send at least one family member to earn money in the mining sector.

Several of the study sites showed evidence of social learning and adaptive behavior at the community scale. In Ikhtamir the Association of PUGs convened a lessons learned meeting for herders, leading to a list of recommended measures. In one Ikhtamir bag, herders agreed on a plan to rest traditional summer pastures and enforce movements to an alternate summer grazing area, and lobbied the soum government to pass a formal resolution to enforce implementation. In Jinst, soum and bag governors joined together to pass soum resolutions calling for all herders to assist in establishing community hay and fodder reserves before the winter

Table 7

Herders’ plans for the year immediately following the dzud. Data are percent of survey respondents in each soum.

	Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan	Total
Where do you plan to live in the coming year?					
Countryside in current soum	93.8	77.8	96.3	81.3	89.2
Soum center	0	5.6	3.7	12.5	4.3
Aimag center	0	11.1	0	0	2.2
Ulaanbaatar or other city	6.3	5.6	0	6.3	4.3
How do you expect to make your living in the coming year?					
In the coming year, I will continue to herd livestock for a living	90.6	88.2	92.6	75	88.0
In the coming year, I will do a different job	18.75	23.5	22.2	43.75	25
In the coming year, someone in my household will work in mining	3.1	0	3.7	50	10.8
What are your plans for rebuilding your herd?					
Look for livestock to buy to rebuild herd	12.9	33.3	14.8	33.3	20.9
Wait for herd to regrow at its natural rate	67.7	50	66.7	40	59.3
Other (includes no plans to grow herd, plan to focus on quality of livestock not quantity)	19.4	16.7	18.5	26.7	19.8



Fig. 3. Lessons from last year's dzud motivated herders to prepare hay from Tsagaan Gol (September 2010). Jinst soum administration prepared 15 tons of hay from this area with assistance from local school and preschool teachers, the hospital and governor's office. This scale of hay harvesting was not implemented in the past and this year almost all the government employees took part in this activity. Photographer and caption-writer: Monkhyargal, Environmental Inspector, Jinst Soum.

of 2010 (Fig. 3). Herders in Jinst also discussed among themselves the need to limit livestock numbers and cull fat animals in the fall. In Undur Ulaan and Bayantsagaan herders discussed in focus groups the potential benefits of stronger and more formalized collective action, but had not yet taken initiative to implement it.

Nor did government or NGOs in these soums facilitate any formal social learning activities to help herders reflect upon the dzud and consider how to change their behavior in the future.

7. Discussion

Our analysis revealed that vulnerability to dzud for Mongolian herding communities is a function of complex interactions between physical, biological, socio-economic and institutional factors within and across levels (Fig. 4, Table 8). As Fig. 4 illustrates, national level economic and political changes contribute to regional poverty, weakened collective action, loss of traditional knowledge and limited cross-level institutions. National to global climate changes contribute to increasing drought, declining surface water and increased dzud frequency. The combination of these physical, socio-economic and institutional factors at a regional level lead to poor pasture and animal conditions, lack of coordinated pasture management and winter preparations locally. Regional physical and institutional factors affect local dzud exposure, particularly in the form of incoming otor herds, and local dzud sensitivity, through their influences on local human and environmental conditions. Our findings highlight how cross-boundary and cross-level dynamics in the form of hooved dzud and potential perverse incentives in dzud relief aid can be a source of vulnerability. We also found that dzud creates an opportunity for learning and positive transformations, which suggests that strategic interventions following a dzud can help increase adaptive capacity.

Overall, we foresee three possible response pathways following the dzud, each with different implications for future system

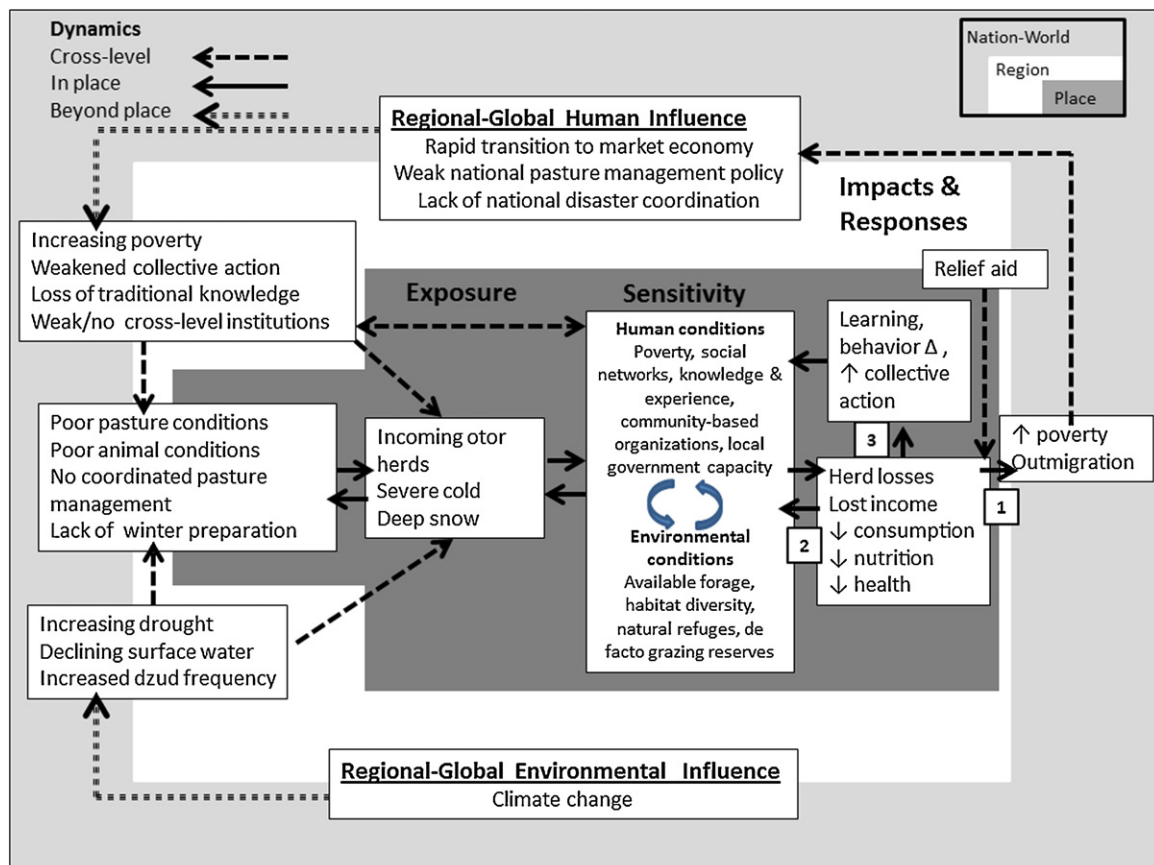


Fig. 4. Using Turner et al.'s (2003) vulnerability framework, we depict the local, regional and cross-level factors and interactions that determine vulnerability in the four Mongolia case study sites. The numbers in the boxes on the right hand side of the figure are alternative response pathways. See text for further explanation.

Table 8
Sources of dzud vulnerability at different levels of social organization.

Scale	Level		
	Household	Community	Cross-Level
Physical	<ul style="list-style-type: none"> • Inadequate livestock shelter 	<ul style="list-style-type: none"> • Snow depth • Coldness • Drought • Limited water availability • Poor summer/fall forage • Limited habitat diversity (lack of sufficient haying areas, natural refuges, de facto grazing reserves) • "Hoofed dzud" 	<ul style="list-style-type: none"> • Climate change affecting water availability, drought frequency and possibly dzud frequency
Biological	<ul style="list-style-type: none"> • Poor animal condition 	<ul style="list-style-type: none"> • Poor summer/fall forage • Limited habitat diversity (lack of sufficient haying areas, natural refuges, de facto grazing reserves) • "Hoofed dzud" 	
Socio-economic	<ul style="list-style-type: none"> • Lack of knowledge/experience • Poverty level • Lack of alternative or supplemental income opportunities 	<ul style="list-style-type: none"> • Poverty rate • Limited alternative employment opportunities 	<ul style="list-style-type: none"> • Increasing aid dependence may reinforce poverty and stifle initiative
Institutional	<ul style="list-style-type: none"> • Weak bonding social capital (ties to relatives and close friends) • Weak bridging and linking social capital (ties to local or regional government, NGOs, donor projects) 	<ul style="list-style-type: none"> • Little mutual assistance and informal cooperation • No formal collective action or community-based organizations • Weak and/or reactive local government • Weak coordination between local government, NGOs, donor projects, and herder communities 	<ul style="list-style-type: none"> • Weak or non-existent cross-level pasture management institutions • Weak disaster management and coordination

function (Fig. 4). (1) *Migrate out*. Herders who lost their livelihoods may leave the sector and potentially the region. This decline in the number of households and livestock may act as a stabilizing feedback at the local level, though outmigration of large numbers of herders who relocate to other regions or the capital city may be a source of cross-level vulnerability at the national level. Also, if too many herders leave, the community may lack sufficient population to sustain local human and social capital. (2) *Rebuild herds*. Herders and local governments may passively wait for herds to rebuild, repeating the boom-bust cycle when the next dzud arrives. We hypothesize that this pathway could result in an amplifying feedback, as in recent history herds have recovered to numbers exceeding the previous peak, with significant impacts on pastures, before the livestock population is once again decimated by a subsequent dzud. Unchecked, this boom-bust cycle may eventually lead to an undesirable regime shift if an ecological degradation threshold is crossed before the next dzud. (3) *Actively adapt*. Finally, either on their own or as the result of targeted program interventions, herders and local governments have the opportunity to learn from this dzud, and to put their learning into action by implementing the ideas they expressed in focus groups and surveys by improving livestock quality and reducing quantity and improving collective action for pasture management. However, the success of such social learning at the local level will depend upon cross-level learning and the development of stronger cross-level institutions to manage pastoral mobility, as well as continued investments in developing livestock markets and value-added processing. There also exists the potential for an initial set of adaptive measures to be "too successful," if the system becomes over-reliant on a limited set of strategies (Alimaev and Behnke, 2008) and fails to establish norms for continual learning and adaptation.

7.1. Mobility, reciprocity and cross-level institutions

Norms of reciprocity are central to Mongolian herding culture and underlie fundamental strategies such as otor movements during dzud and drought (Fernández-Giménez, 2000, 2002; Marin, 2010). In the context of dzud responses, norms of reciprocity, especially regarding sharing pasture with herders on otor from other areas, can be essential to survival of those who are moving, but, as our case studies show, they can also increase exposure and vulnerability of communities who are hosting incoming otor herds.

Thus, at a local spatial level and short (one winter) time period, otor is adaptive and beneficial for the herders making the move, and can be harmful (and potentially maladaptive) for those receiving otor herders. Over a more extensive spatial level, otor may enable survival of a larger regional herd, even if it leads to more losses locally. Similarly, while otor may have detrimental impacts on receiving herders in the short term, if these herders benefit from reciprocity by being welcomed by their neighbors when they flee a future disaster, it may help them in the future to be generous in the present. To fully assess the implications of reciprocal pasture use during disasters, we need to know more about the long-term social impacts of otor. Does otor strengthen ties between herders from different soum, expanding their networks, building social capital, and reducing vulnerability? Or does it increase conflict and weaken incentives for local collective action, potentially increasing vulnerability? If pastures that local herders collectively reserve through intentional cooperative action are consumed by otor herders from other soum, does this reduce or eliminate the incentive for these local herders to participate in collective pasture management? Further, research has shown a clear relationship between wealth and mobility among Mongolian pastoralists. Distant otor movements in a disaster are a strategy that primarily benefits well-off herders who can afford to make them (Marin, 2010; Murphy, 2011), and the poor and less powerful households that cannot move are most vulnerable to the "hoofed dzud" wealthy households may create.

To balance the negative impacts and positive benefits of otor reciprocity, and protect the rights of poorer and less powerful herders, cross-level institutions are essential. Our case studies specifically point to the perils of unregulated otor movements during dzud and the way that this can increase the vulnerability of receiving communities if they are not prepared with designated otor reserves and cross-boundary agreements cannot be effectively monitored and enforced. Mobility and reciprocity are critical strategies to reduce vulnerability to dzud (Marin, 2010; Murphy, 2011). In order for these strategies to work without significant damage to host soum pastures and livelihoods, strong cross-boundary and cross-level institutions are needed that designate soum, aimag, and national otor reserves, specify conditions for their use, and ensure that the terms of agreements between soum are respected. These institutions must be flexible enough to be adaptable to local conditions but structured enough to provide clear guidance and enforcement authority.

7.2. Dynamics of aid dependency and emergency preparedness

With each dzud, calls for aid are widely publicized and stark images of frozen livestock carcasses litter the internet and international press. There is no doubt that dzud often results in high livestock mortality and associated human suffering for Mongolia's pastoralist population. In the midst of a dzud disaster humanitarian aid can make an important difference in the physical and mental well-being of herder households, when efforts are well-coordinated and the right kind of assistance is delivered at the right time. However, poorly targeted assistance and opaque distribution criteria can lead to local conflict and resentment in the short-term, and, over the longer term, may perpetuate a dependency syndrome and lead to strategic poverty on the part of some households. If herders engage in strategic behavior to obtain external aid, this could lead to a vicious cycle of increasing vulnerability and aid dependence because poor households are more vulnerable to dzud losses, according to the results of our survey. It is difficult to determine whether such strategic behavior is actually occurring, or whether the rhetoric we encountered regarding dependency and poverty is part of an ongoing public discourse in Mongolia about the "deserving" and "undeserving" poor (Mearns, 2004), underlain by a cultural narrative of the "lazy herder" (Annika Erickson, personal communication). What is more certain is that donor investments are likely to have a more lasting impact on the resilience of Mongolian pastoral social-ecological systems when they focus on longer term investments such as strengthening local institutions for collective action, which in turn improve pasture management, organize herders to prepare for winter, help diversify income sources, strengthen herders' local and external social networks, and sponsor forums for social learning and knowledge exchange (Batkhishig et al., 2011), rather than short-term emergency aid. Over 2000 formal community-based herder organizations have formed in Mongolia since 1999 with support from 14 different donor projects (Batsaikhan et al., 2010; Mau and Chantsalkham, 2006), suggesting that there is ample experience available about how to implement such programs successfully and pitfalls to avoid. One emergent lesson is the need to attend to the way in which local politics may influence the implementation of formal collective action to the detriment of more economically or socially marginalized households (Murphy, 2011; Upton, 2008). Our findings suggest that livestock insurance may also help to mitigate dzud impacts on household income, consumption and social networks, potentially preventing families from falling deeper into poverty. It is unclear, however, how these insurance schemes will affect rangeland health if herders restock more rapidly than in the past.

A final lesson from our case studies, especially Jinst and Bayantsagaan, is the importance of local government cooperation and coordination with herder organizations, local NGOs, and donor agencies and staff. Neither herder-led organizations nor local governments with their current limited resources, staff, and capacity, can alone effectively manage pastures or respond to disaster such as dzud. It is imperative that local governments learn the value of communicating with and supporting herder-led initiatives, and that herder groups pro-actively share information with local governments. Similarly, when local governments and aid organizations do not effectively communicate and coordinate with each other in disaster response, aid may be mis-allocated or may not be distributed at all. Cross-sectoral cooperation of different types of organizations is essential to reducing dzud vulnerability.

7.3. Adaptive capacity: capturing opportunities for positive system transformation

A fundamental characteristic of resilient systems is their capacity to learn, adapt and "live with change" (Berkus et al.,

2003). Often, opportunities for learning and system change occur during the reorganization phase of the adaptive cycle—the period of chaos that follows a system "release" (Walker and Salt, 2006). Dzud is a recurrent natural disaster in Mongolia, one that herders have learned to live with over centuries, employing many customary adaptive strategies. In the current situation, dzud interacts with other sources of stress and change including economic shocks, institutional transformations, and the emerging effects of climate change, all of which place additional stress on the system and may limit the effectiveness of traditional coping and adaptive strategies. However, dzud also provides an opportunity for learning and positive system transformation.

Among our four case studies, we observed one clear example where a past dzud contributed to building community resilience to the most recent dzud. Jinst was severely affected by the 1999–2002 dzud, losing 75% of the local herd. Between 2004 and 2008, with financial support and technical assistance from the SGMP, six herder groups were organized and implemented grazing management improvements, pasture monitoring, and small enterprise development in the soum. In the 2009–2010 dzud, Jinst herders and local government were among the best-prepared, most proactive, and demonstrated the strongest informal and formal collective action. Surveyed households in Jinst experienced the smallest losses in the 2010 dzud. Jinst's experience demonstrates that herders can learn from dzud experiences and with appropriate support, can use this opportunity to make adaptive changes that increase resilience to future shocks. This is not to say that such community-based organizations are a panacea. As others have shown, the benefits of community-based management are not always equitably distributed within groups, not all herders have access to participate in these programs, and some of these groups do not endure beyond the withdrawal of donor support (Batkhishig et al., 2011; Fernandez-Gimenez et al., 2008; Murphy, 2011; Upton, 2008; Batsaikhan et al., 2010). However, the Jinst case does illustrate the potential benefits and sustainability of herder groups in Mongolia, and the role they can play in strengthening adaptive capacity, and ultimately resilience.

Our focus group, photovoice and survey data all illustrate that many herders in our other 3 study sites are aware of the need for change and ready to learn. Many participants emphasized the need to reduce livestock numbers, improve animal quality, and enhance collective action to harvest and store hay, protect reserve pastures more effectively, and allow overused summer pastures to rest and regrow. The 2 years following dzud, while memory is still fresh, are a critical window of opportunity to initiate and fortify support for investments that encourage collective and individual action for improved pasture and herd management, and strengthen networks for knowledge exchange and other forms of cooperation. Two important considerations here are the economic consequences of reducing stocking rates, and the impact of return intervals of extreme events for learning. Worldwide, there is continued debate about the trade-offs between different stocking rate strategies for rangeland conditions and profitability, with recent evidence from some systems demonstrating that stocking rates that improve rangeland conditions are less profitable (Dunn et al., 2010), while others show that conservative stocking rates can be more profitable in highly variable environments (O'Reagain et al., 2011). What is clear is that herders have little incentive to reduce stocking rates if they have no way to compensate for the lost income (Shang et al., 2012). However, a "wait and see" strategy, such as that represented by pathway 2 (rebuild herds), while economically rational in the short term, is more likely to lead to degradation in the longer term (Foran and Stafford Smith, 1991) and undesirable system transformation. Fortunately, the relatively short (and decreasing) return interval between dzud events in Mongolia makes it more likely that learning will occur, in contrast

to parts of Australia, where the return interval between disasters is longer than the generation time of managers, limiting opportunities for learning from past disasters (Stafford-Smith et al., 2007).

7.4. Global implications for dryland livestock systems

The challenges of vulnerability to climate disasters in our case study sites are not unique to our sites or to Mongolia. Rather, they echo the struggles of other variable and low productivity pastoral and ranching systems around the world, in both developing and developed nations. The first challenge is the apparently conflicting needs for secure rights to key resources, especially forage reserves (e.g. winter pasture and dzud reserves) and flexible forage access in times of need (e.g. otor movements), which create cross-boundary and cross-level governance dilemmas in pastoral systems worldwide (Fernández-Giménez, 2002; Nkedianye et al., 2011; Turner, 2011). Though pastoralists have managed these conflicting demands successfully in a variety of different ways, increasing land fragmentation (Nkedianye et al., 2011), land privatization (Li and Huntsinger, 2011), nationalization (Alimaev and Behnke, 2008), and even well-intentioned common pool resource management policies that fail to grasp the nuances of pastoral mobility and reciprocity arrangements (Turner, 2011) threaten the viability of pastoral mobility institutions and increase vulnerability to climate disasters. Although common property regimes are often thought most appropriate for facilitating pastoral mobility, recent studies of agistment arrangements in Australia demonstrate that mobility and reciprocity can serve as successful strategies for dealing with spatial and temporal variability even in private property systems (McAllister et al., 2011b, 2006, 2011a). These same studies suggest that the level of variability across space and over time influences the suitability of different types of arrangements, with increasing reliance on relationships of trust and reciprocity as variability increases. Our Mongolia cases illustrate that community-based pasture management alone is insufficient to solve this challenge, and support the contention that carefully crafted, context-specific, nested, cross-level and cross-boundary institutions are essential to maintaining mobility, reciprocity, flexibility, and the social ties that both facilitate and are strengthened by pastoral movement patterns (Turner, 2011; Galvin, 2008). Our findings also suggest that more research is needed to understand the dynamic relationships between pastoralists' local and extra-local social networks, livestock mobility, and access to pastoral resources, especially the consequences of power asymmetries within and between networks at different levels of social organization, and the implications for development of robust, equitable and just community-based and co-management regimes.

The second challenge is the “perverse incentives” embedded in disaster relief policies and programs. The criteria and strategies for dzud disaster relief aid distribution in Mongolia are feared by some to create perverse incentives by rewarding herders with assistance who do not adequately prepare for winter, and withholding assistance from those who are proactive and conscientious in their winter preparations. To avoid this dynamic, in some areas aid is distributed equally among all herders, resulting in too little assistance to make a meaningful impact. Discourse about perverse incentives is not unique to Mongolia. Similar arguments have been made about the effects of misguided drought relief policies in the US (Coppock, 2011; Dunn et al., 2005), Australia (Botterill, 2003; Ha et al., 2007), and southern Africa (Vogel et al., 2010), including strikingly similar statements by Australian pastoralists about their colleagues who failed to prepare adequately for drought (Wahlquist, 2008). Further, the financial “bailout” approach of some government drought policies is thought to undermine efforts to promote more proactive drought planning and management (Vogel et al., 2010).

These discourses on drought and dzud relief, perverse incentives, “lazy herders,” and the moral hazards of relief aid raise the broader policy question and third challenge: who bears the risk for climate disasters and who is responsible for disaster preparation and recovery? How can actors at each level of social organization be encouraged to behave proactively and assume appropriate responsibility for preparedness, while ensuring that there is a broad humanitarian safety net in place to prevent permanent loss of livelihoods and food security? What functions of disaster preparation and response should be the responsibility of individual producers, local or national government, civil society, and donor organizations? And which mechanisms—market-, community- or state-led—will most efficiently and effectively promote preparedness and facilitate timely and effective response?

A comprehensive analysis of climate disaster policy in Mongolia and beyond is outside the scope of this article, but our results, considered together with experiences from other systems, suggest some key considerations with respect to the Mongolian situation specifically. First, individual livestock producers ultimately bear the risk and responsibility for dzud preparedness. But in order to act they need access to timely and accurate information, technology, and labor, as well as appropriate incentives. Information, technology, labor and incentives, in turn, can be provided as functions of informal and formal community institutions (information, technology and labor), local and sometimes national government (information and incentives), and civil society and donor organizations (information, technology, and capacity building for community institutions). Pasture management, otor arrangements, monitoring local pasture conditions, and determining the criteria and identification of households for aid distribution are appropriate responsibilities for local government in tandem with community groups and civil society organizations, while national government provides the legal framework and mandates for pasture management, trans-boundary otor movements, and pasture monitoring, and the social safety net for the most severely affected households.

Market incentives for dzud preparation are as yet poorly developed in Mongolia. If greater responsibility is shifted to individuals and local organizations and away from centralized assistance, this may foster local markets in hay, for example. Index-based livestock insurance, one mechanism for pooling risk, was piloted in 4 aimag in 2006–2009 and expanded to 17 others in 2010. However, observers in other regions are skeptical about the viability of this approach and it is too early to evaluate its effectiveness in Mongolia (Binswanger-Mkhize, 2012). In the longer-term, market incentives will be crucial to supporting shifts in herd composition and increasing livestock quality over quantity. The mechanisms here may involve a combination of market incentives and state policies, such as recent Cooperative Regulations advanced by the Mongolian Parliament that provide a price premium for high-quality collectively marketed camel and sheep wool. Several donor organizations are exploring sustainable cashmere certification to connect herders with markets that will pay a premium for sustainably produced products (Cédric Brussac, Mongolia Country Director, Agronomes et Vétérinaires sans Frontières, personal communication, 2011). Certification, niche marketing and payment for ecosystem services are all relatively recent market-based mechanisms to promote sustainable livestock production, and although such methods hold promise (Bohlen et al., 2009; Goldstein et al., 2006; Greiner et al., 2009; Nardone et al., 2004), there are also many challenges (Bullock et al., 2011; Bulte et al., 2008; Lipper et al., 2010). As in many remote arid and semi-arid regions, a major impediment in Mongolia remains the limited potential to diversify rural economies, which limits herders' alternatives.

8. Recommendations

Our analysis of the sources of dzud vulnerability leads us to four primary policy recommendations for government and donors. First, policies and programs must promote increased individual responsibility for dzud preparedness and reduce reliance on government and donor aid. This will require improvements in information distribution (e.g. weather, forage and market forecasts and technical advice), technology (e.g. tractors) and infrastructure (e.g. hay storage barns), and appropriate policy and economic incentives. In addition to technical information and access to breeding stock, economic incentives in particular are critical to enabling herders to act on their intent to focus on livestock quality over quantity. Thus programs and policies that actively test and rigorously evaluate the effectiveness of different market incentive programs (e.g. cooperative marketing, value-added processing, sustainability certification, payment for ecosystem services) should be a high priority. Second, coordination and cooperation among actors within and across levels and sectors must be improved. Cooperation among herders, and between herders, local governments, and civil society organizations and donors is critical to solving within-soum pasture management issues, coordinating dzud preparations, and developing and implementing effective disaster management plans, including appropriate and transparent targeting of emergency assistance. Third, donor programs and government policies should emphasize strengthening adaptive capacity at the community level, rather than providing emergency aid. Our analysis suggests that an effective investment to accomplish this objective is sustaining and scaling out support for formal community-based herder organizations, with the caveat that additional improvements are needed to assure equitable access to the benefits of these programs for all herders. Finally, dzud preparation and response at all levels of government depends critically on clear yet flexible policies to guide and capacity to implement pastureland governance across multiple levels. As national policies for pastureland tenure and management are revised, it is important to include provisions for designation of dzud (otor) reserves at the local, aimag and national levels, and effective and enforceable mechanisms to coordinate and regulate otor movements between different soum and aimag. Because the spatial and temporal variability in both pasture production and dzud varies across Mongolia's territory, the specific cross-boundary arrangements may vary in different regions. However, there is a need for a broad and clear policy framework to provide an enabling legal environment and guidelines for locally negotiated arrangements and the authority to enforce them. Ideally, this national-level policy framework would be developed with input from actors across the different levels, from herders to soum and aimag governments to the relevant ministries and agencies at the national level.

Acknowledgements

This work was supported by the World Bank Social Development Department and World Bank East Asia Sustainable Development Department with financing from the Trust Fund for Environmentally and Socially Sustainable Development (TFESSD), a multi-donor trust fund supported by Finland and Norway. Additional support was provided by the Center for Collaborative Conservation at Colorado State University. We are grateful for research assistance provided by Mr. Tsogoo and Ms. Khishigdorj, as well as the cooperation of herders, local government and project staff in our four study sites. Robin Mearns and Robin Reid provided insightful comments on a draft of this manuscript.

References

- Adger, W.N., 2006. Vulnerability. *Global Environmental Change* 16, 268–281.
- Agrawal, A., 2010. The role of local institutions in adaptation to climate change. In: Mearns, R., Norton, A. (Eds.), *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*. The World Bank, Washington, DC.
- Alimaev, I.I., Behnke, R.H., 2008. Ideology, land tenure and livestock mobility in Kazakhstan. In: Galvin, K.A., Reid, R.S., Behnke, R.H., Hobbs, N.T. (Eds.), *Fragmentation in Semi-arid and Arid Landscapes: Consequences for Human and Natural Systems*. Springer, Dordrecht, The Netherlands.
- Angerer, J., Han, G., Fukisaki, I., Havstad, K., 2008. Climate change and ecosystems of Asia with emphasis on Inner Mongolia and Mongolia. *Rangelands* 30 (3), 46–51.
- Armitage, D., 2007. Building resilient livelihoods through adaptive co-management: The role of adaptive capacity. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-management: Collaboration, Learning and Multi-level Governance*. UBC Press, Vancouver, BC.
- Batima, P., Natsagdorj, L., Gombluudev, P., Erdentsetseg, B., 2005. Observed climate change in Mongolia. *AIACC Working Paper*, 13. AIACC.
- Batkhisig, B., Oyuntulkhuur, B., Altanzul, Ts., Fernández-Giménez, M.E., 2011. A case study of community-based rangeland management in Jinst Soum, Mongolia. In: Fernández-Giménez, M.E., Wang, X., Batkhisig, B., Klein, J., Reid, R.S. (Eds.), *Restoring community connections to the land: Building resilience through community-based rangeland management in China and Mongolia*. CABI, Wallingford, UK.
- Batsaikhan, U., Binswanger-Mkhize, H.P., Himmelsbach, R., Schuler, K., 2010. Fostering the Sustainable Livelihoods of Herders in Mongolia via Collective Action. Swiss Agency for Development and Cooperation SDC, Ulaanbaatar.
- Bayasgalan, B., Mijiddorj, R., Gombluudev, P., Oyunbaatar, D., Bayasgalan, M., Tas, A., Narantuya, T., Molomjamts, L., 2009. Climate change and sustainable livelihood of rural people in Mongolia. In: Devisscher, T., O'Brien, G., O'Keefe, P., Tellam, I. (Eds.), *The Adaptation Continuum: Groundwork for the Future*. ETC Foundation, Leusden, The Netherlands.
- Begzsuren, S., Ellis, J.E., Ojima, D.S., Coughenour, M.B., Chuluun, T., 2003. Livestock responses to droughts and severe winter weather in the Gobi Three Beauty National Park, Mongolia. *Journal of Arid Environments* 59, 785–796.
- Berkes, F., Colding, J., Folke, C. (Eds.), 2003. *Navigating Social–Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.
- Binswanger-Mkhize, H.P., 2012. Is there too much hype about index-based agricultural insurance? *Journal of Development Studies* 48 (2), 187–200.
- Bohlen, P.J., Lynch, S., Shabman, L., Clark, M., Shukla, S., Swain, H., 2009. Paying for environmental services from agricultural lands: an example from the northern Everglades. *Frontiers in Ecology and the Environment* 7 (1), 46–55.
- Botterill, L.C., 2003. Uncertain climate: The recent history of drought policy in Australia. *Australian Journal of Politics and History* 49 (1), 61–74.
- Bullock, J.M., Aronson, J., Newton, A.C., Pywell, R.F., Rey-Benayas, J.M., 2011. Restoration of ecosystem services and biodiversity: conflicts and opportunities. *Trends in Ecology & Evolution* 26 (10), 541–549.
- Bulte, E.H., Boone, R.B., Stringer, R., Thornton, P.K., 2008. Elephants or onions? Paying for nature in Amboseli, Kenya. *Environment and Development Economics* 13, 395–414.
- Cash, D.W., Adger, W.N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, Young, O., 2006. Scale and cross-scale dynamics: Governance and information in a multi-level world. *Ecology and Society* 11 (2):8 [online] URL: <http://www.ecologyandsociety.org/vol11/iss2/art8>.
- Chapin, S.F., Folke, C., Kofinas, G.P., 2009. A framework for understanding change. In: Chapin, S.F., Folke, C., Kofinas, G.P. (Eds.), *Principles of Ecosystem Stewardship: Resilience-based Natural Resource Management in a Changing World*. Springer, New York.
- Coppock, D.L., 2011. Ranching and multiyear droughts in Utah: Production impacts, risk perceptions, and changes in preparedness. *Rangeland Ecology & Management* 64 (6), 607–618.
- Cumming, G.S., Norberg, J., 2008. Scale and complex systems. In: Norberg, J., Cumming, G.S. (Eds.), *Complexity Theory for a Sustainable Future*. Columbia University Press, New York.
- Dorligsuren, D., Batbuyan, B., Bulgamaa, D., Fassnacht, S.R., 2011. Lessons from a territory-based community development approach in Mongolia: Ikhtamir Pasture User Groups. In: Fernández-Giménez, M.E., Wang, X., Baival, B., Klein, J., Reid, R. (Eds.), *Restoring Community Connections to the Land: Learning from Community-based Rangeland Management in China and Mongolia*. CABI, Wallingford, UK.
- Dunn, B.H., Smart, A.J., Gates, R.N., Johnson, P.S., Beutler, M.K., Diersen, M.A., Janssen, L.L., 2010. Long-term production and profitability from grazing cattle in the northern mixed grass prairie. *Rangeland Ecology & Management* 63 (2), 233–242.
- Dunn, B., Smart, A., Gates, R., 2005. Barriers to successful drought management: Why do some ranchers fail to take action? *Rangelands* 27 (2), 13–16.
- Eakin, H., Luers, A.L., 2006. Assessing the vulnerability of social–ecological systems. *Annual Review of Environment and Resources* 31, 365–394.
- Fernández-Giménez, M.E., Batbuyan, B., 2004. Law and disorder: Local implementation of Mongolia's Land Law. *Development and Change* 35 (1), 141–165.
- Fernández-Giménez, M.E., 1999. Sustaining the steppes: a geographical history of pastoral land use in Mongolia. *The Geographical Review* 89 (3), 315–342.
- Fernández-Giménez, M.E., 2000. The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. *Ecological Applications* 10 (5), 1318–1326.

- Fernandez-Gimenez, M.E., 2002. Spatial and social boundaries and the paradox of pastoral land tenure: A case study from postsocialist Mongolia. *Human Ecology* 30 (1), 49–78.
- Fernandez-Gimenez, M.E., Baival, B., Batbuyan, B., 2012. Understanding resilience in Mongolian pastoral social–ecological systems: adapting to disaster before, during and after the 2010 dzud—Final report. The World Bank, Washington, DC/Ulaanbaatar.
- Fernandez-Gimenez, M.E., Kamimura, A., Batbuyan, B., 2008. Implementing Mongolia's land law: progress and issues. Final report to the Central Asian Legal Exchange. Center for Asian Legal Exchange, Nagoya University, Nagoya, Japan.
- Fernandez-Gimenez, M.E., LeFebvre, S., 2006. Mobility in pastoral systems: Dynamic flux or downward trend? *International Journal of Sustainable Development and World Ecology* 13, 1–22.
- Fernandez-Gimenez, M.E., Swift, D.M., 2003. Strategies for sustainable grazing management in the developing world. Paper read at Rangelands in the New Millennium, VIth International Rangelands Congress, 26 July–1 August, 2003, at Durban, South Africa.
- Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social–ecological systems. *Annual Review of Environment and Resources* 30, 441–473.
- Foran, B.D., Stafford Smith, D.M., 1991. Risk, biology and drought management strategies for cattle stations in central Australia. *Journal of Environmental Management* 33, 17–33.
- Galvin, K.A., 2008. Responses of pastoralists to land fragmentation: social capital, connectivity and resilience. In: Galvin, K.A., Reid, R.S., Behnke, R.H., Hobbs, N.T. (Eds.), *Fragmentation in Semi-arid and Arid Landscapes: Consequences of Human and Natural Systems*. Springer, Dordrecht, The Netherlands.
- Goldstein, J.H., Daily, G.C., Friday, J.B., Matson, P.A., Naylor, R.A., 2006. Business strategies for conservation on private lands: Koa forestry as a case study. *Proceedings of the National Academy of Sciences of the United States of America* 103 (26), 10140–10145.
- Greiner, R., Gordon, I., Cocklin, C., 2009. Ecosystem services from tropical savannas: economic opportunities through payments for environmental services. *Rangeland Journal* 31 (1), 51–59.
- Gunderson, L.H., Holling, C.S., 2002. *Panarchy*. Island Press, Washington, DC.
- Ha, A., Stoneham, G., Harris, J., Fisher, B., Strappazzon, L., 2007. Squeaky wheel gets the oil: Incentives, information and drought policy. *Australian Economic Review* 40 (2), 129–148.
- Holling, C.S., Meffe, G.K., 1996. Command and control and the pathology of natural resource management. *Conservation Biology* 10, 328–337.
- IFRC, 2010. Mongolia Cold waves, Disaster Relief Emergency Fund operation final report. International Federation of Red Cross and Red Crescent Societies (IFRC), Ulaanbaatar Office, Ulaanbaatar.
- Li, W.J., Huntsinger, L., 2011. China's grassland contract policy and its impacts on herder ability to benefit in Inner Mongolia: Tragic feedbacks. *Ecology and Society* 16 (2). [online] URL: <http://www.ecologyandsociety.org/vol16/iss2/art1/>.
- Lipper, L., Dutilly-Diane, C., McCarthy, N., 2010. Supplying carbon sequestration from West African Rangelands: Opportunities and barriers. *Rangeland Ecology & Management* 63 (1), 155–166.
- Marin, A., 2010. Chasing the rains: Mongolian pastoralists' vulnerability and adaptation to climate change in 'the age of the market', Institute of Geography, University of Bergen, Bergen, Norway.
- Mau, G., Chantsalkham, G., 2006. Herder group evaluation, policy options for the Government of Mongolia. UNDP Sustainable Grasslands Program, Ulaanbaatar.
- McAllister, R.R.J., Gordon, I.J., Janssen, M.A., Abel, N., 2006. Pastoralists' responses to variation of rangeland resources in space and time. *Ecological Applications* 16 (2), 572–583.
- McAllister, R.R.J., Holcombe, S., Davies, J., Cleary, J., Boyle, A., Tremblay, P., Stafford Smith, D.M., Rockstoh, D., LaFlamme, M., Young, M., Rola-Rubzen, M.F., 2011a. Desert networks: A conceptual model for the impact of scarce, variable and patchy resources. *Journal of Arid Environments* 75, 164–173.
- McAllister, R.R.J., Tisdell, J.G., Reeson, A.F., Gordon, I.J., 2011b. Economic behavior in the face of resource variability and uncertainty. *Ecology and Society* 16 (3), 6 URL: <http://dx.doi.org/10.5751/ES-04075-160306> [online]
- Mearns, R., 1996. Community, collective action and common grazing: the case of post-socialist Mongolia. *Journal of Development Studies* 32 (3), 297–339.
- Mearns, R., 2004. Sustaining livelihoods on Mongolia's pastoral commons: Insights from a participatory poverty assessment. *Development and Change* 35 (1), 107–139.
- Mearns, R., Norton, A. (Eds.), 2010. *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*. The World Bank, Washington, DC.
- Morinaga, Y., Tian, S.F., Shinoda, M., 2003. Winter snow anomaly and atmospheric circulation in Mongolia. *International Journal of Climatology* 23 (13), 1627–1636.
- Murphy, D.J., 2011. Going on otor: disaster, mobility and the political ecology of vulnerability in Uguumur, Mongolia. Department of Anthropology, University of Kentucky, Lexington, KY.
- Nardone, A., Zervas, G., Ronchi, B., 2004. Sustainability of small ruminant organic systems of production. *Livestock Production Science* 90 (1), 27–39.
- Niamir-Fuller, M. (Ed.), 1998. *Managing Mobility in African Rangelands: The Legitimizing of Transhumance*. Intermediate Technology Publications, London.
- Nkedianye, D., de Leeuw, J., Ogutu, J.O., Said, M.Y., Saidimu, T.L., Kifugo, S.C., Dickson, S.K., Reid, R.S., 2011. Mobility and livestock mortality in communally used pastoral areas: the impact of the 2005–2006 drought on livestock mortality in Maasailand. *Pastoralism: Research Policy and Practice* 1, 17. In: <http://www.pastoralismjournal.com/content/1/1/17>.
- NSO, World Bank, 2001. Participatory Living Standards Assessment 2000. National Statistical Office of Mongolia and World Bank, Ulaanbaatar.
- O'Regain, P., Bushell, J., Holmes, B., 2011. Managing for rainfall variability: long-term profitability of different grazing strategies in a northern Australian tropical savanna. *Animal Production Science* 51 (3), 210–224.
- Peters, D.P.C., Pielke Sr., R.A., Bestelmeyer, B.T., Allen, C.D., Munson-McGee, S., Havstad, K.M., 2004. Cross-scale interactions, nonlinearities, and forecasting catastrophic events. *Proceedings of the National Academy of Sciences* 101 (42), 15130–15135.
- Reading, R., Bedunah, D., Amgalanbaatar, S., 2006. Conserving biodiversity on Mongolian rangelands: implications for protected area development and pastoral uses. In: Bedunah, D., McArthur, E.D., Fernandez-Gimenez, M.E. (Eds.), *Rangelands in Central Asia: Proceedings of the Conference on Transformations, Issues and Future Challenges*. USDA Forest Service Proceedings RMRS-P 39. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO, pp. 1–17.
- ReliefWeb, 2010. Mongolia: Severe Winter—Dzud. (Jun 2010). U.N. Office for the Coordination of Humanitarian Affairs.
- Reynolds, J.F., Smith, S.D.M., Lambin, E.F., Turner, B.L., Mortimore, M., Batterbury, S.P.J., Downing, T.E., Dowlatabadi, H., Fernandez, R.J., Herrick, J.E., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F.T., Ayarza, M., Walker, B., 2007. Global desertification: Building a science for dryland development. *Science* 316 (5826), 847–851.
- Robinson, L., Berkes, F., 2011. Multi-level participation for building adaptive capacity: Formal agency–community interactions in Northern Kenya. *Global Environmental Change* 21, 1185–1194.
- Shang, Z.H., Gibb, M.J., Long, R.J., 2012. Effect of snow disasters on livestock farming in some rangeland regions of China and mitigation strategies—a review. *The Rangeland Journal* 34, 89–101.
- Siurua, H., Swift, J., 2002. Drought and Zud but no famine (yet) in the Mongolian herding economy. *Ids Bulletin—Institute of Development Studies* 33 (4), 88–97.
- Stafford-Smith, D.M., McKeon, G.M., Watson, I.W., Henry, B.K., Stone, G.S., Hall, W.B., Howden, S.M., 2007. Learning from episodes of degradation and recovery in variable Australian rangelands. *PNAS* 104 (52), 20690–20695.
- Sternberg, T., 2010. Unravelling Mongolia's extreme winter disaster of 2010. *Nomadic Peoples* 14 (1), 72–86.
- Tachiiri, K., Shinoda, M., Klinkenberg, B., Morinaga, Y., 2008. Assessing Mongolian snow disaster risk using livestock and satellite data. *Journal of Arid Environments* 72 (12), 2251–2263.
- Templer, G., Swift, J., Payne, P., 1993. The changing significance of risk in the Mongolian pastoral economy. *Nomadic Peoples* 33, 105–122.
- Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America* 100 (14), 8074–8079.
- Turner, M.D., 2011. The new pastoral development paradigm: engaging the realities of property institutions and livestock mobility in dryland Africa. *Society and Natural Resources* 24 (5), 469–484.
- Upton, C., 2008. Social capital, collective action and group formation: developmental trajectories in post-socialist Mongolia. *Human Ecology* 36, 175–188.
- Vogel, C., Koch, I., Van Zyl, K., 2010. A persistent truth—reflections on drought risk management in Southern Africa. *Weather Climate and Society* 2 (1), 9–22.
- Wahlquist, A., 2008. Media representations and public perceptions of drought. In: Botterill, L.C., Fisher, M., Collingwood, (Eds.), *Beyond Drought: People, Policy and Perspectives*. CSIRO, Vic., Australia.
- Walker, B., Salt, D., 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press, Washington, DC.
- Wang, C., Burris, M.A., 1997. Photovoice: concept, methodology, and use for participatory needs assessment. *Health Education and Behavior* 24 (3), 369–387.
- WISP, n.d. Pastoralism IUCN World Initiative for Sustainable Pastoralism (WISP) (cited November 4, 2011). Available from http://www.iucn.org/wisp/pastoralist_portal/pastoralism/.