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Lessons from the Dzud: Community-Based Rangeland Management Increases the Adaptive Capacity of Mongolian Herders to Winter Disasters

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Summary. — We investigated the role of formal community-based natural resource management (CBNRM) in responding and adapting to the 2009–10 winter weather disaster in Mongolia, by comparing herders' adaptation strategies and adaptive capacity in communities with and without formal CBNRM. Livestock mobility and forage and hay storage were the most important strategies for limiting livestock loss, but these depended on resource pooling and exchange strategies. CBNRM herders demonstrated greater adaptive capacity than non-CBNRM herders, due to greater knowledge exchange, information access, linking social capital, and proactive behavior. Social factors mediate and institutional constraints limit the implementation of adaptive strategies in Mongolia.

Key words — climate change, adaptation, community-based natural resource management, pastoralism, natural disaster, Mongolia

1. INTRODUCTION

Theory and past research suggest that community-level institutions can play a key role in both the management of natural resources (Agrawal & Chhatre, 2006; Bromley, 1992; Chhatre & Agrawal, 2008; Ostrom, 1990), including rangelands (Fernandez-Gimenez, Wang, Batkhishig, Klein, & Reid, 2011; Fabricius & Koch, 2004), and in adaptation to climate change (Agrawal, 2010). However, few studies have assessed community adaptive capacity in the face of catastrophic weather events expected to increase in intensity and frequency with climate change, or evaluated the role of community-level institutions in fostering adaptive capacity. Further, there has been little consensus on the benefits and outcomes of community-based natural resource management (CBNRM) (Brosius, Tsing, & Zerner, 2005; Kellert, Mehta, Ebbin, & Lichtenfeld, 2000). This is especially true for externally-facilitated community-based institutions in rangeland systems, where spatial boundaries around resources are often fuzzy and permeable, and user group membership is negotiable and contingent (Addison, Davies, Friedel, & Brown, 2013; Cleaver, 2000, 2002; Fernandez-Gimenez, 2002; Turner, 2011). This study advances understanding of the role of local institutions, and specifically donor-initiated CBNRM institutions, in adaptation to climate change, through a study of four Mongolian herder communities' responses to a winter weather disaster in 2009–10.

Mean annual temperature in Mongolia has increased 2.1 °C over the past 70 years, among the strongest warming signals on Earth (Dagvadorj, Natsagdorj, Dorjpurev, & Namkhainyam, 2009). Climate change is also expected to increase the frequency and intensity of severe winter weather, or *dzud* (Bayasgalan *et al.*, 2009; Fernandez-Gimenez, Batkhishig, & Batbuyan, 2012). In dzud, deep snow, severe cold or other conditions make forage inaccessible or unavailable and lead to high livestock mortality (Begzsuren, Ellis, Ojima, Coughenour, & Chuluun, 2003; Siurua & Swift, 2002; Tachiiri, Shinoda, Klinkenberg, & Morinaga, 2008). Dzud is a recurring natural event that limits the growth of Mongolia's livestock population and causes loss of human life and livelihoods. In the dzud events of 1999–2002 and 2009–10 the country lost 30% and 20% of the national herd, respectively. In the 2010 dzud, 28% of Mongolia's population was affected (IFRC, 2010), primarily herders, who comprise one third of the country's population. Increasing frequency and severity of dzud, together with more gradual warming and drying, will likely create significant challenges for Mongolia's herders and rural communities. Enhancing the adaptive capacity of rural Mongolian communities to climate change is therefore a pressing issue for economic, humanitarian, and environmental reasons. Further, the lessons learned from Mongolia's experience can inform development in other highly variable dryland systems susceptible to extreme weather events.

Rural Mongolian communities experience poverty rates in excess of 30% (Coulombe & Altankhuyag, 2012; Griffin, 2003; Nixson & Walters, 2006), and most rural inhabitants depend directly or indirectly on livestock husbandry for their

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livelihoods, making them vulnerable to extreme weather events. Following Mongolia's abrupt transition to democracy and a free-market economy in 1990, formal pasture management institutions dramatically weakened with the dissolution of herding collectives (Fernandez-Gimenez, 1999; Fernandez-Gimenez & Batbuyan, 2004; Mearns, 1996; Upton, 2009), as did state structures for managing natural disasters such as dzud (Siurua & Swift, 2002; Sternberg, 2010; Templer, Swift, & Payne, 1993). The devastating impacts of a series of severe winters in 1999–2003, coupled with perceived increases in grazing-related environmental degradation, led to the formation of some 2,000 formal community-based rangeland management organizations, established with financial and technical support of various donor and NGO projects (Mau & Chantsalkham, 2006).

In this article, our objectives are threefold. First, we describe the adaptive strategies herders used to prepare for and respond to dzud and constraints to their implementation. Second, we assess the adaptive capacity of herder communities with and without formal CBNRM institutions. Finally, we explore the mechanisms through which formal CBNRM improves adaptive capacity. We hypothesized that Mongolian herders possess traditional knowledge and management strategies to cope with a variable and severe climate, but that recent institutional and socio-economic changes may impose new constraints on their implementation or offer new opportunities for innovation. Further, we hypothesized that herders who participate in formal CBNRM organizations would demonstrate greater adaptive capacity than those who do not. Before introducing our study sites and methods, we briefly review key works on adaptation and adaptive capacity, CBNRM, and Mongolian rangeland institutions.

2. ADAPTATION, ADAPTIVE CAPACITY AND ITS MEASUREMENT

Adaptation is the set of actions, attitudes, activities, and decisions that enable individuals, groups, or systems to persist in the face of current or future change or shocks (Agrawal, 2010; Nelson, Adger, & Brown, 2007). Coping refers to short-term responses that allow survival of a given disaster (Yeh, Nyima, Hopping, & Klein, 2013). Agrawal (2010) argues that livelihood adaptation to climate change among the rural poor requires strong local institutions as well as improved cross-scale interactions among institutions operating at different levels, and identifies 5 key strategies for adaptation employed by the rural poor: mobility, storage, diversification, resource pooling, and exchange. Agrawal further asserts that local institutions shape adaptation in critical ways, and that our current knowledge about the role of institutions in climate change adaptation is very limited. Many pastoralists use a similar set of strategies to deal with the inherent variability in their biophysical and social environments (Fernandez-Gimenez & LeFebre, 2006; Fernandez-Gimenez & Swift, 2003). In this paper we draw on qualitative and quantitative evidence to describe the adaptive strategies used by herders in the face of dzud. This paper complements and expands on work by Upton (2012) and Yeh *et al.* (2013), who employed similar frameworks to analyze herder adaptive capacity in Mongolia's Gobi region and coping strategies on the Tibetan Plateau, respectively.

Adaptive capacity is the ability to experiment, innovate, and learn, and to act on new information in response to change and disturbance (Armitage, 2005; Engle, 2011; Smit & Wandel, 2006). Whereas coping and adaptation tend to be reactive, and can even lead to maladaptive outcomes (Engle, 2011; Robinson & Berkes, 2011), adaptive capacity is associated with the ability to think ahead and take proactive measures in anticipation of future change, by applying lessons learned from past experiences. Community-level adaptive capacity is also strongly associated with capacity for collective action—a group's ability to overcome incentives for individual maximizing behavior and free-riding to pursue shared goals in the interest of the group (Adger, 2003; Armitage, 2005). High levels of social capital, in turn, are thought to facilitate collective action, which also serves to further build networks and relationships of trust and reciprocity that define social capital (Ostrom, 1997; Wagner & Fernandez-Gimenez, 2008). Effective local leadership may contribute to adaptive capacity by helping to mobilize individuals to prepare for and respond to disasters and resolve conflicts (Armitage, 2005). Access to diverse sources of information and opportunities for knowledge exchange contributes to adaptive capacity by exposing individuals to new ideas and technologies and perpetuating place-based traditional knowledge (Armitage, 2005; Berkes, Colding, & Folke, 2003).

With growing awareness of the need to adapt to as well as mitigate climate change, assessments of climate change vulnerability and adaptive capacity have proliferated at household (Brown *et al.*, 2013; McDowell & Hess, 2012; Notenbaert, Karanja, Herrero, Felisberto, & Moyo, 2013), community (Brockhaus, Djouri, & Locatelli, 2013; Eakin, 2005; Goldman & Riosmena, 2013; Hung & Chen, 2013; Robinson & Berkes, 2011; Yeh *et al.*, 2013), regional (Schneiderbauer, Pedoth, Zhang, & Zebisch, 2013), and national (Mongolian Ministry of Environment and Green Development, 2013) levels. Although frequently acknowledged as critical (Agrawal, 2010; Engle, 2011), relatively few studies have examined the institutional factors associated with greater and lesser adaptive capacity at the community level (Agrawal, 2010; Berkes & Jolly, 2002; Engle & Lemos, 2010; Goldman & Riosmena, 2013; Robinson & Berkes, 2011; Upton, 2012). Assessing adaptive capacity is challenging, in part because the ability to adapt can only truly be measured after an event or process that requires change in order for a system to persist. Engle (2011) proposes that adaptive capacity can be assessed by exploring system responses to past disasters or stresses in relation to attributes or indicators that theory predicts should increase adaptive capacity. Thus, an ideal assessment of community adaptive capacity would measure how key household or community characteristics, such as well-being, alter following a shock or change, coupled with measurement of adaptation behaviors that would help to explain post-shock variation in well-being. Following this logic, we would expect households or communities with high adaptive capacity to take actions in response to change that enable them to maintain well-being to a greater degree than those with lower adaptive capacity. Based on the theoretical linkages outlined above, we expect high levels of social capital, access to diverse information sources and knowledge networks, and strong local leadership to predict higher levels of preparedness for and innovation in response to shocks and changes.

3. COMMUNITY-BASED NATURAL RESOURCE MANAGEMENT

Community-based natural resource management is the management of natural resources by local people and for their benefit, as well as for resource health. Historically, many common pool resources were managed in this fashion, and often

these management regimes were successful (Ostrom, 1990), if success is defined by long-term persistence of communities and their resource base. More recently, CBNRM and its cousins, co-management, collaborative resource management, and community-based conservation, have been adopted as the dominant paradigms for rural development and conservation. Under this paradigm, the well-being of people and the resources they depend upon are understood to be interdependent, and the success of development is contingent on the success of resource conservation, and vice versa. The CBNRM narrative has become as powerful, persuasive and persistent, some argue, as the "tragedy of the commons" narrative it supplanted (Blaikie, 2006; Murray Li, 2002).

Although evidence demonstrates the success of many customary CBNRM regimes (Bromley, 1992; Ostrom, 1990), and some more recently created ones (Agrawal & Chhatre, 2006; Measham & Lumbasi, 2013; Western & Wright, 1994), questions have also been raised about the effectiveness of CBNRM (Kellert *et al*., 2000), its potentially negative social outcomes (Kamoto, Clarkson, Dorward, & Shepherd, 2013), and the assumptions embedded in CBNRM practitioner and scholarly discourse, including the categories of "community" (Agrawal & Gibson, 2001) and "customary" institutions (Upton, 2009). Under government decentralization, devolution of management authority to local government may fail to meaningfully involve local people (Jiang, 2006), result in overlaying formal legal institutions on informal customary ones (Benjamin, 2008), or supplanting such institutions (Turner, Ayantunde, Patterson, & Patterson, 2012), with implications for social capital and community capacity for conflict management. Externally-driven CBNRM projects may lead to capture or control of benefits by elites within the target communities (Kamoto *et al*., 2013), corruption (Brockington, 2008; Klooster, 1999), and an "institutional blueprint" approach to project design and implementation, which fails to appreciate the variability among local contexts, and the flexible and contingent ways that individual agents and social groups continually construct, negotiate, and deploy customary institutions (Cleaver, 2000, 2002; Turner, 2011). Rangeland/pastoral social-ecological systems (SESs) present special challenges for CBNRM because grazing resources are spatially extensive and productivity varies greatly across space and over time, resulting in deliberately vague grazing territories. Pastoralists are often mobile and membership in social groups is variable and context dependent. In sum, both resource boundaries and group membership are often intentionally vague and constantly renegotiated, violating key CBNRM institutional design principles (Fernandez-Gimenez, 2002; Turner, 2011).

Despite these critiques and challenges, CBNRM offers an alternative to privatization or rigid state control for many pastoral SESs. Further, in remote rural areas like Mongolia, where climate change impacts are experienced deeply by local inhabitants, formal CBNRM organizations may play an important role in strengthening household and community adaptive capacity (Armitage, 2005; Baival & Fernandez-Gimenez, 2012; Berkes & Jolly, 2002; Robinson & Berkes, 2011). Where both state and extant customary institutions for natural resource or disaster management are weak, formal, donor-initiated CBNRM may help to fill an institutional gap in the short-term, and in the longer-term, may contribute to the ongoing construction of effective management institutions and the networks that support them. Few studies have examined the role of formal CBNRM (Upton, 2012) or decentralized governance (Brockhaus & Kambire, 2009) in climate change adaptation, and Mongolia offers an ideal location to do so, because of the prevalence of CBNRM and the severity of climate change impacts experienced in rural Mongolia.

4. RANGELAND INSTITUTIONS IN MONGOLIA

To subsist in Mongolia's low productivity, high variability environment, pastoralists graze multi-species herds of camels, cattle, horses, sheep, and goats, and require both secure access to stored forage during the winter, and flexibility to move to distant pastures during drought and dzud. These needs have long been met by reserving winter and spring pastures and by reciprocal pasture exchanges in disasters. These practices are supported both by herders' customary rights over their traditional winter/spring pastures and norms of reciprocity that enable access to others' grazing territories, and by formal institutions governing mobility and pasture use.

Before Mongolia's 1921 revolution, formal pasture institutions were embedded in a feudal system where secular and religious nobles controlled territories (*khushuu*) and dictated broad-scale movements and pasture use patterns of their serfs and subjects, while custom governed fine-scale movements. Under the socialist collective system (1950–90), herders tended state-owned, mostly single-species flocks for a salary, within smaller administrative districts called *soum*. A herding collective (*negdel)* within each soum formally allocated pastures, directed seasonal movements and other production activities, and provided transportation, veterinary and social services, and fodder and aid during dzud. After privatization in 1992, livestock were allocated to individuals, but Mongolia's rangelands remain state property used in common by herders in each soum. Technical and social support provided by negdels vanished, leaving herders to shoulder risks individually. Herders transitioned from single-species specialization to tending multi-species private herds (Fernandez-Gimenez, 1999; Sneath, 2003; Upton, 2009).

Mongolia's Land Law authorizes soum governments to regulate stocking rates and seasonal movements, and designate seasonal and emergency reserve pastures; however, many lack the capacity or will to do so. Most families hold long-term leases on their winter/spring campsites, but exclusive possession of pasture is not allowed. The Mongolian Parliament remains mired in debate about the future direction of pastureland policy (Fernandez-Gimenez & Batbuyan, 2004; Upton, 2009).

Today, as in pre-collective times, herders often camp together in *khot ail* of 2 or more households, often kin. Khot ail composition is dynamic and members typically pool their herds to share labor, though animals are individual property. Some scholars recognize the existence of larger self-identified herder neighborhoods (*neg nutgiinhan*) (Mearns, 1996), while others do not (Bruun, 2006). The degree to which such neighborhoods engage in collective economic or management activities remains an open question. The smallest formal administrative-territorial unit is the *bag*, comprising some 100 households with an elected leader.

Formally-organized, externally-facilitated CBNRM in Mongolia emerged in the late 1990s as concerns about degradation escalated. After the dzud of 1999–2003, many donors began to invest in CBNRM, hoping to build on existing informal pastoral institutions. Different approaches to CBNRM design and facilitation were implemented by different donors. Two such contrasting approaches were used in our study sites: the Swiss Agency for Development and Cooperation (SDC)'s Green Gold Ecosystem Management Program (GGEMP), and the United Nations Development Program (UNDP)

Sustainable Grasslands Management Program (SGMP). Both programs aimed to improve pasture management in order to enhance both pasture conditions and herder livelihoods. GGEMP took a territorially-based approach and identified CBNRM group members by first delineating the boundaries of pasture units with soum leaders and herder representatives, and then inviting all herders within these territorial boundaries to participate in Pasture User Groups (PUGs). In contrast, SGMP identified potential herder groups (HGs) based on existing social groupings, often kin-based, and then asked group members to delineate their grazing territories. Both programs provided training, technical assistance, and financial support to groups. PUGs include 50 households on average, and HGs 10–15 households. Both group types undertake various collective actions such as joint pasture management, haymaking, and small enterprise development. Although some PUGs and HGs register as NGOs or cooperatives, they lack official standing as legal entities with exclusive pasture use and management rights. Some groups have worked around this by developing internal management rules, and then lobbying the soum parliament to pass a decree that gives their rule the force of law.

5. STUDY SITES

We assessed adaptive strategies and adaptive capacity related to dzud in four Mongolian soum, two in the mountain-steppe zone of Arkhangai *aimag* (province), Ikhtamir and Undur Ulaan, and two in the desert-steppe region of Bayankhongor aimag, Jinst, and Bayantsagaan (Figure 1). Each pair of soum includes one site where donors helped organize formal CBNRM organizations: GGEMP in Ikhtamir, and the SGMP in Jinst, which we refer to as CBNRM soum. In the non-CBNRM soums, Undur Ulaan and Bayantsagaan, herders cooperated informally, primarily at the khot ail level, but without external financial or technical support or formal organizational structures. Two other donors focused on pastoral risk management were present in all four soums, the World Bank's Sustainable Livelihood Project (SLP) and World Vision, but neither directly organized CBNRM groups.

This paired design enabled us to compare the adaptive strategies and capacity of communities within each ecological zone with and without formal CBNRM. Sites were purposively selected based on dzud severity (moderate to severe) and past research on pre-dzud social and ecological conditions at these sites. The characteristics of each study site are summarized in Table 1. Defining vulnerability as susceptibility to harm (Adger, 2006), and using the percent of household herd lost in 2009–2010 as our primary vulnerability indicator, mean losses per surveyed household were 42.9% in Undur Ulaan, 38.9% in Bayantsagaan, 30.7% in Ikhtamir and 13.7% in Jinst. Based on this finding and an analysis of each community's exposure, sensitivity and response to dzud, we concluded that Undur Ulaan was most vulnerable and Jinst least vulnerable (Fernandez-Gimenez, Baival, & Batbuyan, 2012).

6. METHODS

We used qualitative and quantitative methods to document household and community adaptive strategies and measure adaptive capacity. To assess pre-dzud pasture conditions, we used ecological data collected in 2009 (immediately prior to the dzud) from 3 plots in each of 3 winter pasture areas used by CBNRM herders and 3 used by non-CBNRM herders in each ecological zone ($n = 18$ plots in each ecological zone), where we measured vegetation cover, bare ground, and standing biomass.

To gather data on herders' experience of and response to the dzud, and the role of CBNRM organizations and informal institutions before, during, and after the disaster we interviewed local government officials ($n = 11$), donor project staff ($n = 16$), and leaders of formal CBNRM organizations

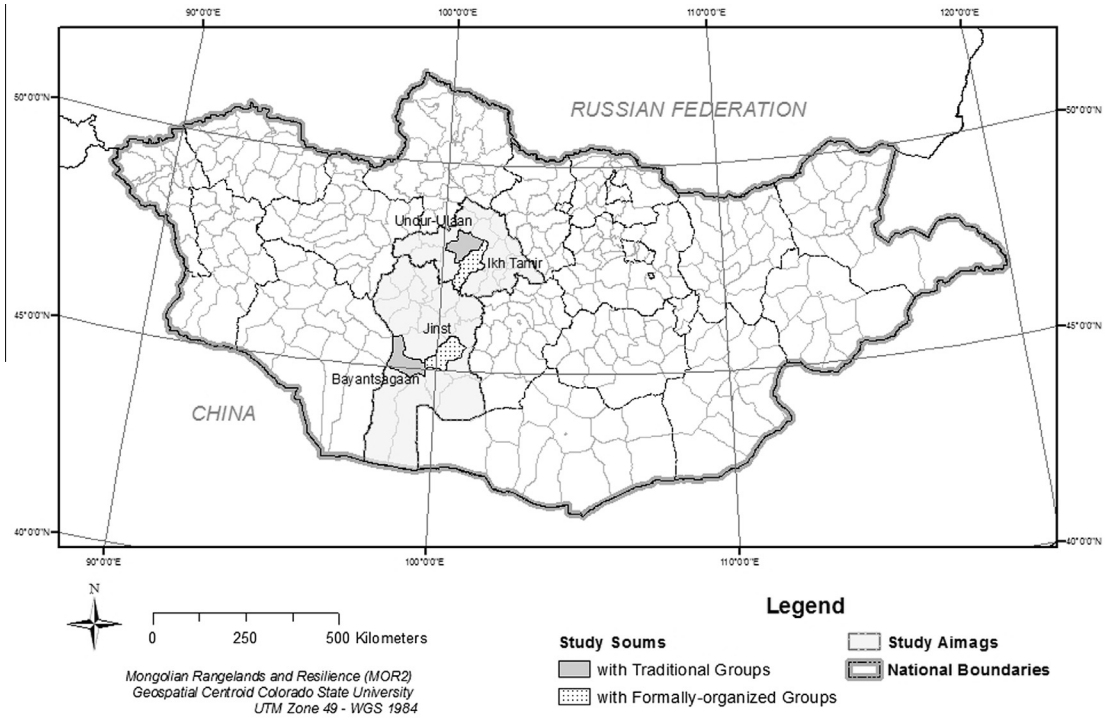

Figure 1. *Map of the study sites indicating soums with and without formally organized CBNRM groups.*

Table 1. *Characteristics of study sites. Climate data sourced from http://www.worldclim.org/current and calculated from the daily average temperature and monthly average precipitation 1950–2000 for 15–18 points in each soum where ecological data were collected. Human and livestock populations sourced from soum governments and the Mongolian National Statistical Office. Standing biomass are original field data*

	Mountain steppe		Desert steppe	
	Ikhtamir	Undur Ulaan	Jinst	Bayantsagaan
Ecological characteristics				
Area (ha)	485,000 ha	440,000 ha	531,264 ha	539,513 ha
Ave. annual temperature	−1.19 °C	−1.96 °C	1.9 °C	−1.9 °C
Ave. annual precipitation	309.5 mm	278.6 mm	127.7 mm	141.2 mm
Biomass Aug. 2009	19.2 g/m^2	18.3 g/m^2	8.2 g/m^2	No data
Biomass July 2011/2012[a]	75.5 g/m^2	46.3 g/m^2	15.8 g/m^2	19.6 g/m^2
Human population (2009)				
Total population	5,247	5,798	2,023	3,401
Total households	1,415	1,570	458	975
Herder households	1,073	1,220	404	672
Livestock population				
Sheep Forage Units (SFU)[b]				
2009 (pre-dzud)	552,636	542,473	149,349	140,563
2010 (post-dzud)	420,516	446,660	100,631	91,552
Number of animals 2010				
Camels	1	0	1,226	845
Cattle	26,723	31,063	702	392
Horses	17,723	16,830	2,069	1,470
Sheep	82,974	94,923	14,865	17,807
Goats	59,042	52,832	67,712	63,198
Herd composition 2010				
(% of SFU)				
Camels	<.001	0	6.1	4.6
Cattle	38.1	41.7	4.1	2.6
Horses	29.5	26.4	14.4	11.2
Sheep	19.7	21.3	14.8	19.5
Goats	12.6	10.6	60.6	62.1
Formal CBNRM Organizations	SDC GGEMP 13 Pasture User Groups	None	UNDP SGMP 6 Herder Groups	None

[a] Biomass was sampled in Jinst and Bayantsagaan in July 2011 and in Ikhtamir and Undur Ulaan in July 2012.
[b] 1 sheep = 1 SFU = 365 kg dry forage/year, 1 cow = 6 SFU, 1 horse = 7 SFU, 1 camel = 5 SFU, 1 goat = .9 SFU (Bedunah & Schmidt, 2000).

($n = 3$); and held focus groups with herders ($n = 91$ participants in 6 focus groups). In non-CBNRM soum we asked bag governors to identify informal groups of herders that shared the same seasonal pasture areas and invited them to focus groups. Interviews and focus groups were audio-recorded and transcribed and transcripts were coded using an initial a priori list of codes based on the research objectives. For this analysis we coded adaptive strategies, constraints to adaptation, and indicators of adaptive capacity. Coded passages were arranged into tables, compared within and across the case study sites, and synthesized and summarized in case study reports for each site. Throughout, we sought discrepant data that contradicted the prevailing trend in the coded passages. Here we report the results of the cross-case comparison and synthesis. The complete case analyses may be accessed on-line,[1] and case summaries are presented in Fernandez-Gimenez, Baival *et al.* (2012).

To assess dzud preparedness, impacts and responses quantitatively at the household level, we implemented a short household survey in 2010, immediately following the dzud. 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, 32 in Ikhtamir, 18 in Undur Ulaan, 28 in Jinst and 16 in Bayantsagaan. More households were surveyed in the soums with CBNRM projects in order to capture variation between CBNRM 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 quantitative indicators of adaptive capacity, we implemented a more in-depth survey in fall 2011 (Jinst and Bayantsagaan) and spring 2012 (Ikhtamir and Undur Ulaan), on a new random sample of households within the same communities ($n = 88$). It was logistically infeasible to resample the same households as in 2010, but there was some overlap in the samples. In the second survey, we collected additional information on management practices, information sources, knowledge networks, collective action, social capital, and income diversity. To quantify management practices we used two summative indices that represented the number of specified practices undertaken by each household. The first index related directly to 13 conventional measures undertaken to prepare for winter (Table 2), and the second to a more general

index of 21 innovative practices (Table 3). We reasoned that herders who plan and prepare for potential winter disasters, and those who actively manage, monitor, or restore natural resources, improve their herd quality or composition, or experiment with alternative production systems demonstrate greater adaptive capacity. We used the innovation and preparation indices as our primary indicators of adaptive capacity.

We also assessed eight intermediary indicators of adaptive capacity identified from the literature (see Section 2 above): structural social capital (bonding and linking networks), cognitive social capital (trust and reciprocity), community leadership, pro-activeness, information diversity, knowledge exchange, and income diversity. We assessed both bonding and linking structural social capital by asking respondents who had helped them during a time of need within the past 5 years. Bonding social capital refers to horizontal ties with individuals of similar social position, including friends, neighbors, and family, and linking social capital refers to vertical ties with individuals or organizations such as experts, government employees, banks, or NGOs. Cognitive social capital was assessed using 6 items on a 3-point Likert-type scale (disagree, neutral, agree) (Table 4). We assessed leadership based on 4 items. As a proxy for collective action, we assessed "pro-activeness," a summative index of 6 items (Table 4). Pro-activeness is an indicator of the respondent's participation in formal and informal collective action and their capacity and propensity to communicate with government officials and technical experts. We also assessed information exchange

Table 2. *Frequency of winter preparedness activities in 2011 in CBNRM member and non-member households in four Mongolian rural districts. Differences assessed using Pearson's Chi-square*

Action	Non-members		CBNRM members		X^2	p	Phi[a]
	Percent	No.	Percent	No.			
Reserve winter pasture	47.5	19	61.2	30	1.676	.195	.137
Reserve spring pasture	35.0	14	63.0	31	7.039	.008	.281
Reserve dzud pasture	35.0	14	40.8	20	.316	.574	.060
Fall or summer otor	35.9	14	53.1	26	2.580	.108	.171
Cull unproductive animals in fall	45.0	18	67.3	33	4.495	.034	.225
Cut hay	62.5	25	93.9	46	13.439	.000	.389
Prepare hand fodder	28.0	7	80.0	28	15.187	.000	.415
Purchase and store grain	82.5	33	75.0	36	.725	.395	.091
Purchase and store concentrate	45.0	18	48.9	22	.129	.720	.039
Purchase and store other feed	10.0	4	23.4	11	2.721	.099	.177
Vaccinate livestock	85.0	34	91.8	45	1.032	.310	.108
Deworm livestock	85.0	34	87.8	43	.143	.705	.040
Treat livestock for external parasites	50.0	20	67.3	33	2.751	.097	.176

[a] Phi is an estimate of effect size interpreted in the same manner as the Pearson r, where a .10 indicates "minimal" relationship, .3 a "typical" relationship, and .5 or greater a "substantial" relationship (Vaske, 2008).

Table 3. *Frequency of innovative practices over previous 5 years in CBNRM member and non-member households. Differences assessed using Pearson's Chi-square*

Action	Non-members		CBNRM members		X^2	p	Phi[a]
	Percent	No.	Percent	No.			
Purchase breeding stock–camels	0	0	4.2	2	1.621	.203	.137
Purchase breeding stock–horses	7.9	3	12.2	6	.437	.509	.071
Purchase breeding stock–cattle	2.6	1	10.4	5	1.981	.159	.152
Purchase breeding stock–sheep	46.7	14	53.5	16	.166	.683	.044
Purchase breeding stock–goats	47.2	17	46.9	23	.001	.979	.003
Intentionally change species composition of herd	42.5	17	38.3	18	.159	.690	.043
Sell animals to reduce herd size	40.0	12	60.0	18	.659	.417	.087
Fence pasture	12.5	5	31.9	15	4.601	.032	.230
Fence hay field	5.0	2	25.0	12	6.524	.011	.272
Fence or improve natural water source	20.0	8	40.8	20	4.426	.035	.223
Dig a new well	15.0	6	29.2	14	2.493	.114	.168
Repair existing well	37.5	15	40.8	20	.102	.750	.034
Plant fodder or grass	7.5	3	18.4	9	2.230	.135	.158
Use fertilizer	7.5	3	20.4	10	2.942	.086	.182
Use irrigation	2.5	1	16.3	8	4.632	.031	.228
Plant garden for food	7.5	3	63.3	31	29.009	.000	.571
Take action to reduce soil erosion	2.5	1	6.3	3	.707	.400	.090
Take action to restore damaged lands or natural resource	0	0	8.3	4	3.492	.062	.199
Take part in formal monitoring of environmental conditions	2.5	1	19.1	9	5.888	.015	.260
Take other action to protect key resource	7.5	3	20.4	10	2.942	.086	.182
Intentionally not breed animals because of dzud	35.0	14	25.5	12	.924	.336	.103

[a] Phi is an estimate of effect size interpreted in the same manner as the Pearson r, where a .10 indicates "minimal" relationship, .3 a "typical" relationship, and .5 or greater a "substantial" relationship (Vaske, 2008).

Table 4. *Reliability of Likert-type scales for indicators of adaptive capacity in four rural Mongolian districts (soum) (n = 89). Leadership and cognitive social capital are measured on a 3-point Likert-type scale where 0 = disagree, 1 = neutral, 2 = agree. Pro-activeness is binary 0 = no, 1 = yes. Knowledge exchange is 0 = no one, 1 = 1–3 people, 2 = more than 3 people*

Scale and Item	Mean	Standard deviation	Cronbach's alpha[a]
Leadership (maximum possible score = 8)	4.98	2.421	.67
My community has good informal leaders whom we trust	1.38	.778	
My community has some knowledgeable and respected people we can turn to for advice	1.43	.841	
I know helpful organizations in my soum who support and collaborate with us	.99	.941	
In my community, the local government pays attention to and listens to us	1.18	.865	
Pro-activeness (maximum possible score = 6)	2.25	1.763	.707
Active member of any soum organization	.41	.494	
Active member of any regional or national organization	.08	.272	
Talked with local authorities about problems in your community	.60	.492	
Talked with experts about rangeland issues	.43	.498	
Joined in collective rangeland improvement or management initiatives	.38	.487	
Joined with other community members to address any other type of problem or issue.	.35	.480	
Cognitive social capital (maximum possible score = 12)	8.5	3.2	.814
People in my community always try to help each other	1.64	.714	
People in my community help each other in times of need	1.59	.705	
Most people in my community are trustworthy	1.70	.571	
People in my community mainly look out for themselves (reverse coded)	1.08	.847	
If given the chance, people in my community will take advantage of others (reverse coded)	1.34	.756	
I am concerned that our community is getting less friendly, people are less connected to each other and not looking out for each other as they used to do (reverse coded)	1.15	.838	
Knowledge exchange (maximum possible score = 8)	2.73	2.061	.807
I know people I can talk with about…			
Livestock health, reproduction, and nutrition	.86	.647	
Livestock marketing	.58	.673	
Pasture rotation and resting	.61	.633	
Disaster preparedness and risk management	.67	.638	

[a] Cronbach's alpha assesses the internal consistency of responses to a set of questions designed to measure a specific concept. An alpha of .65-.70 is usually considered adequate in human dimensions research (Vaske, 2008).

networks, an index of access to 4 different types of information (Table 4) and information diversity, an index of access to 15 different information sources. We reasoned that herders with access to more sources of information on more topics would have greater capacity to adapt (Armitage, 2005; Berkes *et al.*, 2003). Finally, we assessed income diversity using a simple summative index of the number of different income sources reported by each household (out of a possible 16). Income diversity is an indicator of adaptive capacity because herding households with more income sources have alternative or supplemental livelihood options when their main source of income—livestock—is lost or threatened.

In our analysis we first compared the ultimate and intermediate indicators of adaptive capacity among the study communities and CBNRM member and non-member households, and then used multiple regression to explore the causal relationships between CBNRM participation, intermediate indicators, and adaptive capacity. We used ANOVA to compare indicators of adaptive capacity among the 4 study communities, and student's *t*-tests to compare between households that were members and non-members of formal CBNRM organizations. To examine the frequencies of individual management strategies, information and income sources, between CBNRM and non-CBNRM households, we used Pearson's Chi-square.

Next, we conducted multiple regressions to explore the mechanisms through which participation in CBNRM leads to innovation and preparedness. We hypothesized that CBNRM membership leads to improved preparedness and innovation because CBNRM members have greater access to information and opportunities for knowledge exchange, stronger leadership, engage in more proactive behavior, and possess higher levels of both structural and cognitive social capital. Data were analyzed using SPSS 21. Given the small sample, we considered differences significant at a *p*-value of .10.

7. RESULTS

(a) *Adaptive strategies*

(i) *Mobility*

Mobility of different types is a critical strategy before, during, and after dzud. *Otor* is a rapid long-distance movement of all or a portion of the herd and household undertaken to fatten animals in fall or escape a weather disaster such as drought or dzud. Fall otor aims to consolidate fat and increase animal fitness to survive a harsh winter. As such, fall otor is an anticipatory adaptive strategy in advance of disaster. In contrast, winter otor is a coping response during dzud. In fall 2009, more CBNRM member households went on otor (77%) than non-member households (58%) ($X^2 = 3.603$, $p = .058$). Fall otor was significantly associated with lower dzud losses showing it to be an effective strategy (Fernandez-Gimenez, Baival *et al.*, 2012). The same pattern held in 2011, though less strongly (Table 2). Many herders also went on otor during the winter; however, the results of this coping strategy were mixed. Sometimes winter otor helped herds survive, and other times it led to increased exposure due to lack of warm and dry shelter at the otor destination. In sites like Jinst, with adequate reserve pastures, herders were

less likely to undertake winter otor. We found no differences among wealth groups in the frequency of fall otor, but the wealthiest households were significantly more likely to go on winter otor (74%) than the other two wealth groups (40% for medium households and 29% for poor households) ($X^2 = 9.731$, $p = .008$). Otor movements during an emergency were thus determined in part by wealth, which influences both the need for otor to feed large herds, and the resources available to make otor movements. Kakinuma, Okayasu, Jamsran, and Okuro (2014) found a similar dichotomy in the strategies of households with large *versus* small herds in response to drought. Proactive fall otor was influenced by participation in formal CBNRM organizations. As Murphy (2011) has shown, wealthier households also often hold positions of greater social influence within a community or region, and this power can enhance their ability to negotiate resource access in other districts (Murphy, 2011). Focus groups indicated that use of short-distance otor is related in part to the availability and accessibility of appropriate otor destinations within the soum, which may be limited by lack of water or poor production in drought years.

For the "host" community, incoming otor herders from other communities sometimes create local forage shortages (called "hoofed dzud"), harming the pastures and livelihoods of host community herders (Fernandez-Gimenez, Baival *et al*., 2012). However, most herders are reluctant to turn away visitors during a disaster, knowing that they may have to rely on the generosity of neighboring communities in the next storm. This strong norm of reciprocity underscores the importance of social capital and social networks in maintaining mobility as an adaptive strategy.

In addition to otor movements, regular movements among seasonal pastures and, where possible, alternating between different seasonal pastures in different years, are important to allow plants opportunity for regrowth. Regrowth of winter and spring pastures during summer is essential to allow a winter forage reserve to accumulate. Allowing pastures to rest for a growing season by alternating between different summer pasture areas in different years enables individual plants and plant communities to recover and accumulate stored carbohydrates, which increases resilience to future grazing. As one Jinst HG leader explained, "*Rotational use of seasonal pastures helps us in many different situations, as it preserves not only particular pasture for seasonal use, but it helps the herd to get necessary fat and energy, which in turn improves our livelihood.*"

A final type of mobility is migration to the soum or aimag center or Ulaanbaatar during of following dzud. In our 2010 household survey, the sites with greater vulnerability and more severe losses (Undur Ulaan and Bayantsagaan) experienced higher rates of planned outmigration (22% and 19% of surveyed households, respectively). Most herders expected these moves to be temporary, which suggests that they are more of a coping strategy than an adaptation. However, we do not know if these planned migrations occurred or whether they were temporary or enduring.

(ii) *Storage*

Storage was a widely used and critically important strategy for surviving the dzud. Storage takes the form of stored hay, home-made hand fodder, fodder purchased in advance of the winter, and reserved winter, spring, and dzud pastures. "In vivo" storage in the form of animal weight gain and fat reserves is also critical. Storage may also be in the form of cash savings and stockpiled food supplies. Herders whose wealth is in the form of large herds have an advantage over those who have fewer animals, but they would likely be even better off if they had converted more of their animals to cash by selling them in the fall and banking the proceeds.

Superior survival rates of herds that went on fall otor demonstrate the importance of "in vivo" storage by fattening animals. In the desert-steppe, households that fed stored hay lost 18% of their herd compared to 29% lost by those who did not ($t = 1.701$, $df = 42$, $p = .096$) and those that grazed reserved spring pastures lost 16% compared to 28% lost by those who had no reserves to graze ($t = 2.1$, $df = 40$, $p = .041$). These findings illustrate the direct relationship between storage strategies and household-level dzud outcomes. In 2011, CBNRM herders were significantly more likely to set aside separate spring pasture reserves than non-CBNRM herders (Table 2), although there were no differences in 2009 before the dzud. This suggests that CBNRMs may play a role in learning from disaster and mobilizing members to implement adaptive strategies.

At the soum level, Jinst had a designated dzud reserve pasture, but incoming otor livestock from other soums exceeded its capacity and it lacked adequate water. Following the dzud, the Jinst soum government decided to designate additional reserves. Ikhtamir also designated an area for use by otor herders, but incoming herders refused to stay there. The negative impacts of incoming otor herders on host soum dzud exposure, highlights the need for more effective storage and use of standing forage in soum otor reserves.

(iii) *Diversification*

Diversification can be expressed in a variety of adaptive strategies, including traditional multispecies livestock herds, access to a diversity of pastoral resources (different pasture types, varied topography, riparian and forested areas, salt licks, etc.), income from multiple sources rather than a single livelihood, diverse social networks, and access to a diversity of information sources.

In both study regions the dzud disproportionally affected particular types of livestock (cattle in Akhangai and goats in Bayankhongor), suggesting that a diverse and balanced herd composition is a wise hedge against the risk of dzud. Our qualitative data show that access to a diversity of natural resources is important to coping and adaptation. Herders in soums with natural topographical and habitat diversity have an advantage. For example, Jinst herders used natural riparian areas to harvest hay and create reserve pastures, whereas Bayantsagaan herders lacked riparian areas. In Undur Ulaan, sheltered forest slopes provided a refuge for herds that otherwise might have perished.

Income diversification is also an important adaptive strategy. Although there were no significant differences between soum or CBNRM members and non-members in the number of income sources reported, there were differences in several categories of non-livestock income. In Bayantsagaan, over 40% of households surveyed obtained some income from mining in 2010. In Ikhtamir and Jinst, growing vegetables for home consumption and sale is an increasingly important livelihood strategy. Over half the surveyed households in both soums planted gardens, and 12% (Ikhtamir) and 28% (Jinst) reported some income from vegetable gardening, compared to zero income from gardening in the other two soums. Sixty-three percent of CBNRM member households raised vegetables compared to 7.5% of non-member households ($X^2 = .179$, $p = .002$, Table 2). CBNRM members were also more likely to obtain income from small businesses ($X^2 = 4.325$, $p = .038$).

Herders in soum with formal CBNRM have more diverse social networks and more sources of information than those

from non-CBNRM soum. For example, herders in CBNRM soum were significantly more likely to have obtained information from a professional expert ($X^2 = 15.17$, $p = .002$), formal training or seminar inside the soum ($X^2 = 23.231$, $p < .001$), or training outside the soum ($X^2 = 8.156$, $p = .043$). Herders in these soums also reported knowing more people to whom they could turn for advice on livestock health, reproduction, and nutrition ($X^2 = 26.684$, $p < .001$), livestock marketing ($X^2 = 27.137$, $p < .001$), pasture rotation and resting ($X^2 = 28.706$, $p < .001$), and disaster preparedness and risk management ($X^2 = 24.918$, $p < .001$).

(iv) *Communal pooling*

Communal pooling involves sharing resources, labor, or wealth, distributes risk across households, and improves the efficiency of many production activities. Pooling was a common strategy in the study sites with labor sharing and joint management of pastures and otor reserves being the most common pooling strategies. Labor sharing focused on haying and other winter preparations, and herding during the dzud. A local official in Undur Ulaan described labor and pasture pooling during the dzud: "*During the dzud we saw how herders joined efforts together. They collected yaks and cows as one herd and took them to the forest where there was more forage and shelter. Each took a turn for 1 day; 4–5 families' herds with 400–500 cattle. They were left there for 2 months and they did not bring them back to the main ger [nomadic dwelling]. They had 2 otor gers and 4 people rotated to take care of the animals.*"

Following the dzud some herders began engaging in more joint marketing activities. In 2011 the Mongolian Government passed a resolution to encourage collective marketing, as well as improvement of livestock quality, by committing to provide a premium price for high-quality sheep and camel wool to herders belonging to a marketing cooperative. Formal CBNRM organizations enhanced pooling by organizing many labor sharing and joint resource management activities among their membership, especially hay production and pasture management.

(v) *Exchange and reciprocity*

Norms of reciprocity are central to Mongolian herding culture and support mobility strategies such as otor movements during dzud and drought. 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 they can also increase exposure and overall vulnerability of communities hosting incoming otor herds (Fernandez-Gimenez, Baival *et al.*, 2012).

Mutual assistance among local herders and between herders and more distant kin and friends is potentially critical to coping and adaptive capacity. We found few examples of informal mutual assistance among herders, apart from sharing pastures and campsites with otor herders, and herding labor, as discussed earlier. The strongest evidence for the importance of mutual assistance came from Jinst, where herders supported each other through local networks facilitated by CBNRM organizations, gave aid to distant relatives in more severely dzud-affected locations and received assistance from city kin.

Market exchange allows herders to reduce risk by substituting for other adaptive strategies. For example, market exchange enabled herders to purchase supplemental feed when they lacked stored hay or reserve pastures. In Jinst, herders sold thin livestock in the spring for cash. Remoteness from markets and poor terms of trade limit herders' use of this strategy. However, if markets for hay develop, we may see more buying and selling of locally-produced feed.

Insurance provides herders with a market-based means of distributing risk. In our study, only herders in Jinst and Bayantsagaan had access to livestock insurance, although 81% of herders surveyed expressed interest in purchasing it. Access to credit enables herders to use market exchange, potentially reducing vulnerability in the short term. Over the longer term, high debt may increase vulnerability or force herders into alternative livelihood strategies. Many herders reported that they were unable to pay back debts due to dzud losses, and high debt levels lead herders to increase their herd sizes and goat numbers in order to pay back loans with cashmere income.

Information and knowledge exchange before, during, and after the dzud is a key strategy that reduces vulnerability and increases adaptive capacity. This strategy can occur at various levels of social organization from exchanges between individual herders and households, to information dissemination within herder organizations or bag, to information provided by and to local, regional, and national governments. It is important for herders to have adequate information both about the local situation (e.g., predicted and current weather and pasture conditions, aid distribution) as well as the situation in the surrounding region and across the country. Technical information about how to prepare for and respond to dzud is critical (e.g., building techniques for shelters, hay harvesting and storage, proper use of supplemental feed, preventive care for animals), as is exchange about dzud experiences and lessons learned, which can influence individual and collective behavior and enhance adaptive capacity. Local, regional, and national governments are important not only as conduits for information going out to herders and to other levels of government, but also as receivers and transmitters of information about the local situation. Local government, in particular, plays a crucial function in documenting the local conditions, severity, and emerging impacts of dzud to higher levels of government and relief organizations. Complete, accurate, and timely information on the local situation is critical to ensure that government and donor assistance goes to the most needy areas. In our cases, we observed both successes (Bayantsagaan) and failures (Ikhtamir) in local government efforts and effectiveness in information exchange before and during the dzud. CBNRM organizations also play a key role in facilitating knowledge exchange and CBNRM members had more opportunities for information exchange than non-members (Table 5).

(b) *Constraints to adaptation*

We identified 5 categories of constraints to adaptation: human capital, social capital, economic, institutional, and environmental. Awareness of these constraints can help focus future policy and investments on eliminating these barriers to adaptation.

(i) *Limited human capital*

In all but one study site herders and local officials identified lack of knowledge and information as a major constraint. For example, some herders who purchased bran to feed during the dzud lacked knowledge of how to prepare it properly before feeding it to livestock, resulting in little benefit to their animals. One local official observed, "*Young people have no knowledge of how to pass a dzud, and there are few old people to pass on the knowledge.*" This observation was typical, and suggests that traditional knowledge that helped herders

Table 5. *Comparison of adaptive capacity indicators between four rural Mongolian districts (soum). Differences assessed using ANOVA. p-Values are the original values uncorrected for multiple comparisons. Only values <0.0045 are statistically significantly different using Bonferroni's correction (.05/11 tests)*

Indicator (scale range)	Ikhtamir ($n = 24$)		Undur Ulaan ($n = 23$)		Jinst ($n = 25$)		Bayantsagaan ($n = 17$)		F	p	Eta-squared[a]
	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error			
Preparedness scale (0–13)	7.91	.360	5.59	.440	8.52	.639	7.24	.566	6.633	.000	.203
Innovation scale (0–21)	4.04	.501	2.05	.407	7.19	.807	5.73	.765	12.653	.000	.336
Information diversity (0–15)	8.52	.501	6.30	.405	9.78	.552	7.88	.539	8.660	.000	.255
Knowledge exchange (0–2)	.656	.086	.1957	.052	1.02	.102	.897	.093	18.290	.000	.392
Pro-activeness (0–6)	2.42	.309	.61	.205	3.79	.324	2.06	.264	22.422	.000	.445
Leadership (0–2)	1.24	.119	.696	.102	1.71	.091	1.35	.083	17.857	.000	.387
Cognitive social capital (0–2)	1.39	.128	1.20	.118	1.57	.086	1.49	.102	2.152	.100	.071
Structural bonding social capital (0–5)	2.30	.398	1.30	.367	3.17	.348	3.00	.343	3.850	.013	.149
Structural linking social capital (0–8)	3.21	.436	1.00	.211	4.23	.378	2.71	.329	9.713	.000	.313
Total structural capital (0–14)	5.00	.498	2.40	.542	7.05	.682	5.71	.513	8.775	.000	.312
Income diversity (0–16)	2.83	.214	2.35	.119	3.08	.215	3.18	.196	3.573	.017	.112

[a] Eta-squared values are generally interpreted as .01 = small effect, .06 = moderate effect, and .14 = large effect.

survive in the past is being lost. Herders in the mountain-steppe focus groups reported that lack of labor and an aging herder population limited their ability to cut and store large amounts of hay, or move long distances to fatten animals on fall otor. Yeh *et al.* (2013) identified similar labor barriers among Tibetan pastoralists coping with snowstorms.

(ii) *Limited social capital*

In many areas of Mongolia informal mutual assistance was weakened by 70 years of authoritarian socialist rule (Mearns, 1996). Although herders commonly cooperate by sharing herding labor within khot ail, and most abide by norms of reciprocal pasture use during disasters, collective action, mutual assistance, and cooperation on a wider scale and across other arenas of social and economic activity are weak. Few herders cooperate on marketing and only herders engaged in formal CBNRM groups manage their pastures collectively in a deliberate fashion, setting a mutually agreed upon schedule for seasonal movements and agreeing to defer use of overgrazed pastures to allow them to recover. Herders who are not CBNRM members have limited social networks comprised primarily of bonding ties with family and neighbors, with few linking ties to technical experts, government officials, or donor project staff.

(iii) *Economic constraints*

Opportunities for income diversification in rural areas are severely limited, access to markets for livestock products is poor, and there is no market differentiation for product quality. "*Someone is gaining from the price difference. Herders sell for 2,000 MNT when the market price is 5,000 MNT. Due to this situation, herders don't care anymore about quality, because there is no price differential for quality*," remarked a project officer in one of the study sites. In addition, most communities do not have machinery such as tractors for haying, and in our study areas, only herders in the desert-steppe had access to livestock insurance. Many herders reported high levels of debt and no savings, supporting other recent accounts (Sneath, 2012). Dependence on relief aid was thought by some to lead to "strategic poverty" (Fernandez-Gimenez, Baival *et al.*, 2012). Disparities and lack of transparency in aid distribution also led to dissatisfaction and dissent among herders.

(iv) *Institutional constraints*

The majority of constraints to adaptation were institutional. Some of these are inherent challenges of collective action such as differing interests of heterogeneous group members. Several interviewees spoke of differing incentives for small- and large-scale producers, with wealthy herders being most reluctant to participate in formal CBNRM organizations. Herders from an Ikhtamir CBNRM focus group reported, "*Those herders who have many livestock stress ones with few livestock. Large numbers with poor quality of animals trample pasture and affect the earth. It is necessary to raise the tax for the herders with a thousand livestock. People are fearful of herders who have a thousand livestock.*[2]" Formal collective action through donor-supported CBNRM projects has demonstrated some success in this study and others (Baival & Fernandez-Gimenez, 2012; Batkhishig, Oyuntulkhuur, Altanzul, & Fernández-Giménez, 2011; Schmidt, 2004; Upton, 2012; Ykhanbai, Bulgan, Ulipkan, Vernooy, & Graham, 2004), but many of the projects initiated during or after the 1999–2002 dzud have ended and the financial and technical support has been withdrawn. Although some groups have persisted without further support (Batkhishig *et al.*, 2011; Upton, 2012), such efforts cannot be effectively scaled out without significant initial technical assistance.

Institutions governing natural resource access, use, and management created constraints in several different ways. The lack of enabling legal environment for community-level pasture possession and management is a constraint to effective CBNRM (Dorligsuren, Batbuyan, Bulgamaa, & Fassnacht, 2011). Organized CBNRM groups have no legal mechanism for exclusive possession and use of their community pastures, even if they have management rights. This diminishes their ability to regulate grazing by non-members, as well as their ability to exclude other land uses, such as mining. Unenforced mining regulations and lack of a legitimate process for public involvement in land use decisions involving commercial mines significantly affected herders in one area of Jinst, where their reserve pastures were destroyed by mining exploration despite herders' protests to local government. Herders' experience with mining in this site threatens to undermine their commitment to and progress toward community-based pasture management because their collective management efforts are undone by exploration activities in which they have no voice.

Absent, unclear, or ineffective policies and regulations to coordinate cross-boundary herd movements (otor) in disasters also undercut local efforts to set aside reserves and coordinate pasture use (Fernandez-Gimenez, Baival *et al.*, 2012). Permanent or semi-permanent relocation of herders from one soum or region to another may also have a seriously destabilizing effect, increasing grazing pressure, demand for services, and competition for pastures, and campsites in the receiving soum.

Finally, poor communication and coordination among different types of organizations and agencies (e.g., donors, NGOs, government) within and across different levels of administration (local, regional, national) limit effective disaster preparation and response (Fernandez-Gimenez, Baival *et al.*, 2012).

(v) *Environmental constraints*

The major environmental constraints relate to the inherent natural endowments of each study soum and changes in the condition or availability of resources. Mountain-steppe soums are inherently more productive, a factor that Brown *et al.* (2013) found influenced household adaptation choices. Jinst and the mountain-steppe soum also encompass diverse habitats, providing areas suitable for hay harvest, mountain pastures, or forests that offer shelter from storms, while Bayantsagaan lacked this diversity. Limited water supplies affected herders' ability to access and use some pastures that would otherwise provide excellent forage reserves or fattening areas.

(c) *Adaptive capacity*

The four study sites differed significantly on all measured indicators of adaptive capacity except cognitive social capital. Jinst scored the highest on almost every indicator, followed by Bayantsagaan and Ikhtamir, with Undur Ulaan scoring lowest on most indicators (Table 5). Similarly, herders belonging to formal CBNRM organizations scored significantly higher on most indicators than those who were not CBNRM members (Table 6). Effect sizes (Cohen's *d*) for most indicators were moderate or strong. CBNRM members and non-members differed most in pro-activeness, leadership, information diversity, and linking structural social capital. There were no differences in cognitive social capital, structural bonding social capital, or income diversity between CBNRM members and non-members.

Specific preparedness and innovation practices also differed between CBNRM and non-CBNRM members. CBNRM members used 7 of the 13 traditional preparedness practices with significantly greater frequency than non-CBNRM herders (Table 3). The greatest differences were in storage-related practices. More CBNRM members prepared hay and hand fodder and set aside spring reserve pastures. Similarly, CBNRM members used 9 of 21 innovative practices more frequently than non-CBNRM members. Of these, CBNRM members were much more likely to plant a garden, take part in formal environmental monitoring, and protect hayfields with fencing.

Our ecological data show that in the summer preceding the dzud (2009), winter pastures in the CBNRM communities of the mountain-steppe had significantly greater vegetation cover (83.9% mean ± 4.9% standard deviation) compared to those in non-CBNRM communities (69.6% ± 9.4%, $t = -4.079$, $p = .001$). In the desert-steppe, litter values were greater in CBNRM (11.1% ± 4.7%) than non-CBNRM pastures (8.4% ± 4.8%, $t = -1.876$, $p = .079$). These differences, although modest, suggest that the practice of protecting reserve pastures may have resulted in greater forage availability in the winter of 2009–10 as well as protecting rangeland health by retaining soil and moisture on site.

Using multiple regression analysis we explored the mechanisms through which CBNRM influences two primary indicators of adaptive capacity: winter preparedness and innovation. When the effects of other variables are held constant, information diversity and pro-activeness were significant predictors of winter preparedness, with the effect of linking structural social capital marginally significant (Table 7). This model explained 37% of the variation in winter preparation. Holding other variables constant, knowledge exchange was a significant predictor of innovation, and information diversity showed a positive association of modest statistical significance. Thirty-one percent of the variation in innovation behavior was explained by this model.

8. DISCUSSION

(a) *Adaptive strategies are interdependent, socially-mediated, and institutionally-constrained*

We hypothesized that herders use traditional knowledge and practices to cope with a harsh and variable environment, but that recent socio-economic and institutional changes may constrain their use or open new opportunities for adaptation. Our results demonstrate how both traditional herding practices and institutions and more recently adopted institutional and technological innovations can be usefully classified into five adaptive strategy categories previously identified in the literature: mobility, storage, diversification, communal pooling, and reciprocity/exchange (Agrawal, 2010; Fernandez-Gimenez &

Table 6. *Results of t-tests comparing adaptive capacity indicators in CBNRM member and non-member households. p-Values are the original values uncorrected for multiple comparisons. Only values <0.0045 are statistically significantly different using Bonferroni's correction (.05/11 tests)*

Indicator	Non-members			CBNRM members			*t*	*df*	*p*	Cohen's *d*[a]
	n	Mean	SE	*n*	Mean	SE				
Preparedness scale	39	6.41	.344	43	8.12	.391	−3.246	80	.002	.72
Innovation scale	36	3.64	.490	43	5.58	.530	−2.653	77	.010	.60
Information diversity	36	6.97	.348	44	9.20	.380	−4.250	78	.000	.96
Knowledge exchange	40	.48	.073	49	.85	.071	−3.614	87	.001	.77
Pro-activeness	40	1.23	.198	48	3.10	.242	−6.009	85	.000[b]	1.26
Leadership	40	.95	.085	49	1.50	.079	−4.742	87	.000	1.01
Cognitive social capital	40	1.31	.086	49	1.50	.074	−1.670	87	.098	.36
Structural bonding social capital	27	2.33	.302	43	2.79	.265	−1.111	68	.270	.28
Structural linking social capital	27	2.15	.260	41	3.71	.305	−3.892	66	.000[b]	.93
Total structural capital	27	4.52	.481	35	6.14	.478	−2.355	60	.022	.61
Income diversity	40	2.68	.126	49	2.98	.150	−1.512	87	.134	.33

[a] Cohen's d values are generally interpreted as .2 = small effect, .5 = moderate effect, and .8 = large effect (Vaske, 2008).
[b] Test assuming unequal variances was used.

Table 7. *Multiple regression models predicting winter preparedness and management innovation*

Independent variables	Dependent variables (adaptive capacity indicators)			
	Preparedness scale		Innovation scale	
	Standardized beta	*p*	Standardized beta	*p*
Structural linking social capital	.236	.065	.098	.468
Cognitive social capital	.087	.448	−.097	.431
Leadership	.023	.895	−.031	.866
Pro-activeness	.270	.054	.102	.491
Knowledge exchange	−.078	.583	.325	.037
Information diversity	.309	.034	.274	.076
Model fit				
F, Adjusted R^2	$F = 7.089$, Adj. $R^2 = .375$		$F = 5.368$, Adj. $R^2 = .308$	

LeFebre, 2006). In this study, some of these categories are primarily composed of direct management actions and practices (e.g., mobility and storage), others relate to natural or accumulated assets (e.g., diversity of habitats and livestock species), and still others to social institutions (e.g., reciprocal pasture exchanges, common pooling of pastures). All five strategies contribute to community and household coping and adaptation in the face of shocks such as severe winter storms. The traditional strategies of livestock mobility and storage of cut hay and standing biomass in reserve pastures are most critical to minimizing livestock mortality in bad winters. These strategies, in turn, are supported by customary institutions that facilitate mobility, including resource pooling and reciprocal and flexible pasture access during disasters. Table 8 illustrates how each strategy is dependent on several others. In order to use diverse pasture resources, such as sheltered forests, herders must move and rely on common pooling or reciprocity to gain access. Maintenance of reciprocal relationships for pasture exchanges requires that the hosting communities share their stored reserve forage or diverse resources, and that guests are able to move their herds to access these resources. Mobility and sharing of diverse and stored resources in turn maintain these social ties, strengthening mutual obligations among different herder households and communities.

This interdependence of traditional adaptive strategies suggests, on the one hand, that these strategies co-evolved and are mutually reinforcing, as other research on pastoral systems indicates (Galvin, 2008). It also implies that this pastoral SES and other similar systems that rely on an interdependent set of adaptive strategies may be particularly vulnerable when one element of the system is weakened or changed. For example, when landscapes are fragmented by changes in land tenure (i.e., privatization) or infrastructure (e.g., rail lines, fences), limiting or altering mobility patterns, this may weaken the associated social networks (Galvin, 2008). Conversely, if social and cultural changes weaken social networks, this may impede herders' access to remote forage reserves and their ability to rely on mobility as an adaptive strategy (Goldman & Riosmena, 2013; Li & Huntsinger, 2011). These changes are not yet widespread in Mongolia, but lessons from transitioning pastoral SESs in places such as Kenya, Tanzania, and China suggest they could occur.

In addition to dependence on social networks, reciprocity, and resource pooling, the ability or propensity to implement some strategies is mediated by household wealth, power, labor and resource access, as well as access to information, knowledge, and technology. Household wealth, social power, and labor are often interrelated, and directly affect mobility and storage. Wealthy households with large herds have a greater need to move, more labor to make moves, and resources to pay for transportation. In addition, they often have more political influence to obtain government help in negotiating resource access outside soum boundaries. Our findings echo those of Murphy (2011) and Upton (2012) in Mongolia and Goldman and Riosmena (2013) in east Africa, where wealth influences pasture access and mobility. Knowledge deficits limit storage if herders do not know how to properly preserve cut hay, feed stored fodder, and technology is limiting if they lack access to haying equipment.

As hypothesized, implementation of adaptive strategies is often constrained by flawed, weak, or absent institutions at higher levels of governance, and by limited local mutual assistance, trust, and experience with economic cooperation. Institutional constraints affect all five adaptive strategies directly or indirectly (Table 8). The effectiveness of mobility is hindered by a lack of clear and enforceable cross-level regulations governing otor movements and reserves. Storage is undermined by failure of otor institutions, but also by lack of legal status and property rights for CBNRM organizations, and unenforced mining regulations. Communal pooling is stymied by the typical challenges of collective action, including heterogeneous interests of community members, lack of trust in economic matters, as well as lack of experience with collective action beyond labor sharing. Lack of sustained financial and technical support for scaling out CBNRM may limit its potential to build adaptive capacity. Weak mutual assistance during disasters is likely due to the fact that most households are overwhelmed with the need to save themselves and their own herds, leaving little ability to assist their neighbors. Limited economic cooperation and scaling out of CBNRM may be partially due to herders' lack of awareness of the benefits of cooperation and lack of training and skills in organizational and financial management. In the following section, we discuss the role of local institutions in adaptation and adaptive capacity, highlighting the potential for local institutions, especially formal CBNRM, to help overcome some of these constraints and open new opportunities for adaptation.

(b) *The role of local institutions in adaptation and adaptive capacity*

In our study sites, formal CBNRM organizations often facilitate the implementation of adaptive strategies that reduce household and community vulnerability to dzud. CBNRM groups in Jinst and Ikhtamir organized members for collective hay harvest and storage, and promoted the protection of winter reserve pastures, which may explain measurable differences

Table 8. *Summary table of adaptive strategies, factors that mediate or constrain implementation of these strategies, and interdependence of strategies*

	Mobility	Storage	Diversity/diversification	Communal pooling	Reciprocity/exchange
Practices, Assets, Institutions that Comprise each Strategy	*Herd movements*	*Forage & fodder*	*Resources*	*Resources*	*Resources*
	Fall otor to fatten animals	Reserve pastures	Riparian areas	Pastures	Reciprocal pasture access
	Winter otor to escape dzud	Cut & store hay	Mountain pastures	Water	Purchase fodder*Livestock*
	Seasonal mobility to rotate pastures*Human migration*	Store purchased fodder*Livestock*	Sheltered forests*Livestock*	Campsites*Labor*	Cull animals in fall
		Body condition (fat reserves)	Multispecies herds*Income/livelihood*	Herding	Sell weak animals in spring*Knowledge exchange*
	Out-migration after dzud	Livestock numbers*Savings*		Haying	
	In-migration of otor herders during dzud	*Other assets*	Vegetable gardens	Childcare*Joint marketing*	*Social capital*
			Mining	*Revolving loan fund*	
			Small business		Norms of reciprocity
			Wage labor*Information*		Trust*Insurance*
					Loans
			Number of sources*Social networks*		*Mutual assistance*
					Donor/government assistance
			No. of bonding ties		
			No. of linking ties*Institutions*		
			Donor projects		
			Organized CBNRM		
Mediating Factors & Constraints	Wealth	Wealth	Wealth	Heterogeneous interests	Wealth
	Power	Power	Power	Lack of experience with collective action	Power
	Resource access	Resource access	Resource access		Poor market access
	Labor	Lack of legal status and property rights for CBNRM	Few economic opportunities	Lack of support for scaling out CBNRM	Weak mutual assistance
	Lack of otor regulations		Lack of knowledge		Lack of trust
		Unenforced mining regs.	Legal restrictions on access to forests		Insurance unavailable
		Lack of water makes reserves unusable			High debt
		Lack of knowledge (e.g., how to feed fodder)			Poor coordination between donors and government
		High debt, no savings			
		Lack of technology (e.g., tractors)			
Dependence on other Strategies	*Pooling, Reciprocity*	*Mobility, Reciprocity*	*Mobility, Reciprocity, Pooling*	*Reciprocity, Storage*	*Mobility, Diversity, Pooling, Storage*

in vegetation cover (mountain-steppe) and litter (desert-steppe) between pastures managed and grazed by CBNRM and non-CBNRM households. CBNRM members were more likely to go on fall otor, an example of the way in which such organizations promoted the use of mobility. Resource pooling was much greater among CBNRM members. CBNRM organizations were instrumental in teaching herders to grow vegetable gardens, which diversified their diet and income streams, and in helping them to develop small businesses. Information sources and opportunities for knowledge exchange were also enhanced by membership in a formal CBNRM organization. CBNRM members were more likely to monitor pastures and take action to protect key resources.

Both qualitative evidence and quantitative analyses indicate that adaptive capacity differed among soums as well as between households that belonged to formal CBNRM organizations and those that did not. Of the four soums, Jinst consistently demonstrated the greatest adaptive capacity, and Undur Ulaan the weakest. Bayantsagaan also scored relatively high on many adaptive capacity indicators, especially bonding and cognitive social capital, and leadership. Despite its remoteness, lack of civil society organizations and formal CBNRM groups, and its vulnerability, herders in Bayantsagaan had strong social networks and local leadership. The local government in Bayantsagaan played an important role in helping herders respond to the dzud, demonstrating that local government institutions as well as civil society and market institutions may play key roles in adaptation.

Based on the quantitative indicators gathered in our household survey, we found strong evidence that households belonging to formal CBNRM organizations were better prepared for winter, more innovative, and scored higher on most indicators of adaptive capacity than non-members. Knowledge exchange and information diversity were the strongest predictors of innovation. Information diversity, pro-activeness, and linking social capital were the strongest predictors of winter preparedness. Interpreting the results of individual *t*-tests and multiple regressions together, it appears that the greater adaptive capacity demonstrated by CBNRM members is explained in part by the role of CBNRM organizations in increasing members' access to information and opportunities for knowledge exchange, mobilizing members to act together to prepare for winter and address other rangeland management and community problems, and expanding their social ties to organizations and experts beyond close family, neighbors, and friends.

We found no significant differences between CBNRM members and non-members in the assistance they received from family and friends (structural bonding social capital), or in their income diversity, and only a small difference in trust and reciprocity (cognitive social capital). These findings are not greatly surprising as most Mongolian herders rely on their ties to family and friends in times of need, the safety net of first resort, even if bonding ties were limited in number in this study (Upton, 2012). Lack of differences in income diversity between members and non-members suggest that formal CBNRM organizations at these study sites have not yet had a major impact on expanding herders' livelihood options.

(c) *Implications for CBNRM*

Scholarship on rangeland CBNRM has been polarized between laudatory case studies (Child & Lyman, 2005; Western & Wright, 1994) and arguments that externally-initiated CBNRM may leave communities worse off, by undermining existing socially-embedded, flexible, and context-specific institutions (Cleaver, 2000, 2002; Turner, 2011). The same is true for Mongolia, where recent research has generated success stories (Leisher, Hess, Boucher, van Beukering, & Sanjayan, 2012; Schmidt, 2004; Ykhanbai *et al.*, 2004), documented ineffectiveness (Addison *et al.*, 2013), and given rise to cautionary tales (Murphy, 2011; Upton, 2008) about formally organized CBNRM. Research reported in this paper gives us the basis for cautious optimism about the role that formal CBNRM institutions can play in strengthening the adaptive capacity of Mongolian pastoral SESs.

We offer this conclusion with several caveats. First, although CBNRM households demonstrated greater adaptive capacity, our data do not definitively show that participation in CBNRM organizations caused these differences. Households that were pro-active, well-informed, and well-connected before the formation of the formal CBNRM organizations were potentially more likely to join these organizations when the opportunity arose. We do know that CBNRM organizations increased levels of collective action, winter preparation, and social learning at the community level, which reduced vulnerability to the 2009–10 dzud in Jinst Soum (Baival & Fernandez-Gimenez, 2012; Fernandez-Gimenez, Baival *et al.*, 2012). Thus, even if formal CBNRM organizations attract households that already have stronger adaptive capacity and build upon this, such formal groups may help to leverage and extend this adaptive capacity to additional households and at the community level.

Second, a major concern among critics of formal rangeland CBNRM has been the potential of formal institutions to cement existing inequalities among households within communities, and to undermine context-based, socially-embedded institutions (Addison *et al.*, 2013; Cleaver, 2002; Turner, 2011). In Mongolia, Murphy found that formal CBNRM organizations may reinforce existing disparities in social power within communities (Murphy, 2011). Upton (2008, 2012) raised questions about who is included and excluded from the opportunity to participate in CBNRM organizations and their benefits, and called for greater transparency. In our study sites, the wealthiest herders with the largest herds were less likely to participate in voluntary CBNRM initiatives, as they perceived little benefit to cooperating with other herders. This dynamic is distinct from one where locally powerful individuals dominate decision-making in participatory initiatives or capture the benefits, but brings its own set of problems. If herders with large herds and who therefore have a disproportionate impact on rangelands do not participate in collective management of pastures, the likelihood of successful CBNRM is slim. Among CBNRM members surveyed in this study, we found that there were no significant differences in wealth (measured in livestock holdings, hard assets, and income) among herders who agreed with the statement "I have benefitted from participating in this group" and those who disagreed. Overall, poorer herders were significantly more likely to agree with the statement "members consider all participants' input equally." These findings suggest there is little elite control or capture of benefits in the groups we studied. However, they do not address the issue of who is included or excluded from participation. Both of these themes deserve further attention in the Mongolian context.

Third, our study and most previous research on community-based institutions in Mongolia have taken the herder household as a unit of analysis and have neither considered intra-household dynamics, nor investigated the gender dimensions of CBNRM. Given the gender dynamics in Mongolian society broadly, the role of gender in CBNRM remains an important and unstudied dimension of both formal and informal CBNRM in Mongolia. Mongolian women achieve higher

levels of education than men (UNDP, 2013). However, women remain underrepresented in elected offices (World Economic Forum, 2012) with only 12.7% of parliamentary seats held by women in 2013. A preliminary gender analysis of CBNRM organizations in Mongolia showed that CBNRM leadership follows this overall pattern, with few female leaders in formal CBNRM organizations or informal herder neighborhoods (Ulambayar & Fernandez-Gimenez, 2013). Further, fewer female-headed households participate in formally organized CBNRM groups than in traditional herder neighborhoods, suggesting that women may have less access to participation in these groups and hence less opportunity to benefit from them (Ulambayar & Fernandez-Gimenez, 2013).

9. CONCLUSIONS AND IMPLICATIONS

Storage and mobility are critical adaptive strategies used by pastoralists in Mongolia and elsewhere. The success of these strategies depends on strong social networks, norms of reciprocity, and well-coordinated institutions to manage livestock movements and pasture exchanges. Innovation, the ability to learn rapidly, and to apply learning to action are fundamental to adaptive capacity. CBNRM organizations in this study enhanced both coping and adaptive capacities by facilitating information access and knowledge exchange, and promoting organized collective action. Major constraints to adaptation are low levels of mutual assistance and endogenous collective action; knowledge deficits; and limited development and implementation of formal policies to govern pasture use and management, pastoral mobility, and recognize the rights and responsibilities of formally organized CBNRM groups.

How can the adaptive capacity of Mongolian pastoral SESs be strengthened? First, given the critical role of social networks and relations of reciprocity to all other adaptive strategies, mutual assistance and knowledge exchange, additional research is needed to understand the structure and function of social networks among pastoralists and between pastoralists and other actors.

Second, our findings that formal CBNRM contributes to stronger and wider networks, knowledge exchange, and collective action, support continued investment and technical assistance for existing CBNRM organizations, and serious consideration of how to scale-out this movement in Mongolia. CBNRM is not a panacea; however, our data demonstrate that it holds promise for increasing adaptive capacity. Further research is needed to fully understand the implications of CBNRM for power relations and gender roles within herding households and communities. Other forums that encourage networking, dialog, and social learning can also contribute to strengthening adaptive capacity and local governments could play a stronger role in providing such venues.

Third, local implementation of adaptive strategies is constrained by institutional obstacles, many originating at levels of governance beyond the local community. The most urgent institutional issues are those that directly affect critical strategies of mobility and storage: (1) lack of legal status and collective pasture possession rights for CBNRM organizations, (2) weak and unenforced regulations governing cross-boundary migrations, and (3) weak and unenforced mining regulations in which herders have no meaningful voice. In implementing institutional reforms care must be taken not to "harden" the "soft" landscape and social boundaries in this extensive pastoral system because doing so may impede herder mobility and reciprocal pasture access (Hobbs, Galvin, Stokes, Lackett, & Ash, 2008; Reid, 2012), and loosen fragile but vital social ties. Improved economic incentives and tools are also urgently needed (Addison & Brown, 2014; Fernandez-Gimenez, Baival *et al*., 2012).

Fourth, our results provide initial evidence of the important role CBNRM organizations could play in ecological monitoring and stewardship, as demonstrated by CBNRM members' participation in formal environmental monitoring and reserving pasture, and resulting differences in vegetation cover between CBNRM-managed and non-CBNRM pastures. Monitoring is critical to adaptation because it detects changes in environmental conditions that signal the need to change management, and provides a way to learn from the results of past actions (Armitage, 2005). We recommend research on the ecological outcomes of CBNRM in Mongolia, participatory development of locally-meaningful and regionally-applicable indicators (Bruegger, Jigjsuren, & Fernandez-Gimenez, 2014), and community involvement in monitoring them (Baival & Fernandez-Gimenez, 2012; Roba & Oba, 2009).

Even the most effective CBNRM organizations are insufficient to solve resource degradation or risk management challenges that span multiple jurisdictions and geographic scales. Cross-boundary and cross-level governance institutions are essential and urgently needed to address the herd mobility dilemmas that increased vulnerability during the 2009–10 dzud (Fernandez-Gimenez, Baival *et al*., 2012). Rangeland assessment and monitoring also must be implemented and integrated across geographic scales and levels of governance in order to detect the cumulative impacts of herd movements and management at a regional scale (Reynolds *et al*., 2007).

NOTES

1. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/08/14/000356161_20120814014813/Rendered/PDF/718440WP0P12770201208.01.120revised.pdf.

2. The herder is referencing the government power to tax livestock. CBNRM groups have no taxation powers in Mongolia.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.worlddev.2014.11.015.