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Dryland Development Paradigm Application for the Study of the Tuin and Baidrag River Basin Social-Ecological Systems in Mongolia

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ABSTRACT: Socio-economic changes and climate change in the last two decades have caused dynamic changes in Mongolia's pastoral systems. To study these dynamics, we applied the Dryland Development Paradigm (Reynolds *et al.*, 2007) as a framework to analyze pastoral social-ecological systems in the Tuin and Baidrag river basins, located in Bayanhongor aimag. Global warming was identified as the most critical slow variable in these drylands. Water resources in the region have already decreased below critical threshold levels, with fewer rivers flowing and lakes drying out. Social-ecological vulnerability has increased more rapidly in the desert steppe region than in other ecological zones in the study area.

KEYWORDS: *Dryland Development Paradigm (DDP), pastoral social-ecological systems, Mongolia*

Introduction

In the past several decades, changes in climate, livestock dynamics and socio-economic factors are interacting in new ways that are altering nomadic land-use systems in Mongolia (Ojima and Chuluun, 2008). In the last seventy years, the annual mean air temperature has increased by 2.14°C in Mongolia (MARCC, 2009) and this warming has intensified in the last two decades. The loss of water points due to global warming (Davaa, 2009) has disrupted traditional nomadic pastoral patterns of seasonal grazing. Increased grazing pressure around the remaining water points has resulted in local overgrazing. These changes have increased the vulnerability of pastoral social-ecological systems. In this paper, we examine the vulnerability of rangelands in river basin areas.

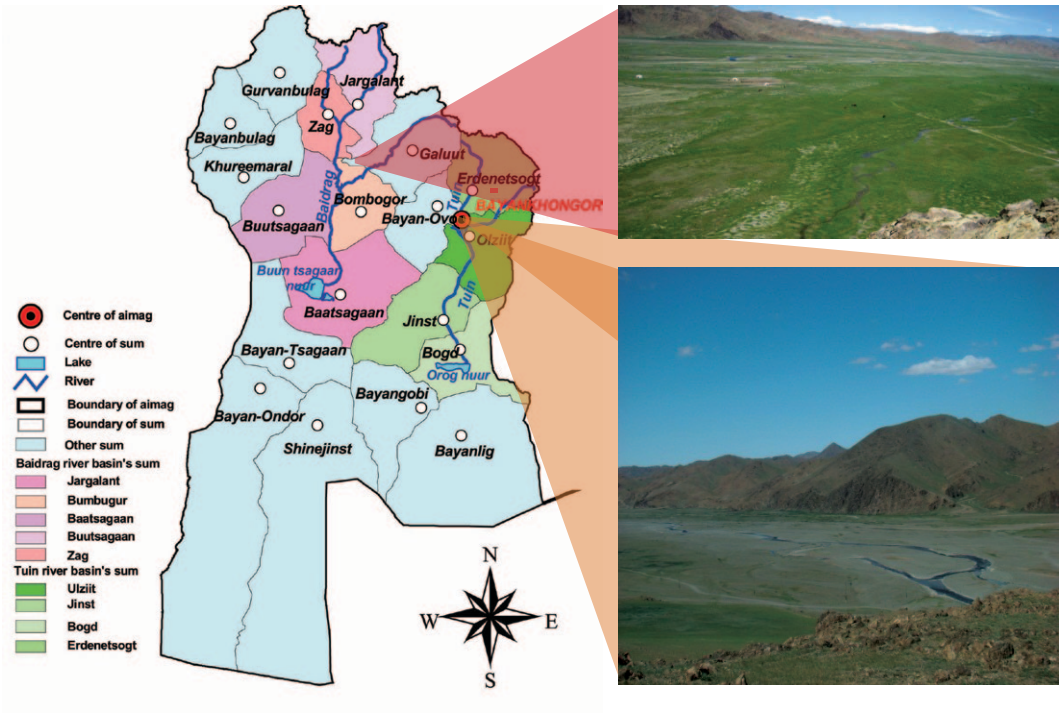

Figure 1. Location of the Tuin and Baidrag river basins in Bayanhongor aimag, Mongolia

Material and methods

Our study areas are pastoral social-ecological systems in the Tuin and Baidrag river basins, located in Bayanhongor aimag province (Figure 1). These two rivers are major rivers located in the south facing slopes of the Khangai Mountains. The Tuin River flows into Lake Orog, and the Baidrag into Lake Boontsagaan. The study area covers different ecological zones: from forest steppe in the high mountains, steppe in the centre, and desert-steppe in the south. These ecological systems were connected not only through natural processes like river flow, but by humans through livestock movements historically (Chuluun and Ojima, 2011).

We used the Dryland Development Paradigm (DDP) (Reynolds *et al.*, 2007) to frame discussions with key stakeholders to understand the main drivers of system dynamics, critical slow variables and thresholds already crossed in pastoral social-ecological systems in our study area. The social survey results were then integrated with socio-economic and climate data analysis. Climate change analysis included warming trends, and drought and *zud* index calculations. Livestock dynamics and composition changes were also included to study land-use and cover change. Social-economic study included the Human Development Index (HDI) and social vulnerability assessments.

The Rangeland Ecosystem Vulnerability Index is a combination of a Drought Index (Natsagdorj and Sarantuya, 2004) and a Rangeland Use Index,

$$\Delta N = \alpha\left(\frac{N - N_o}{N_o}\right)$$

where N is livestock density; and N_0 is the carrying capacity (Mongolian National Atlas, 1990 & 2009); α is a pasture management coefficient, set to 1 in this study (Chuluun *et al.*, 2005).

Results and Discussion

The long-term temperature since 1940 shows a clear warming trend by more than 2^0C in our study area. Intense warming (Figure 2(a)) and the transition to a market economy coincided in the last two decades,

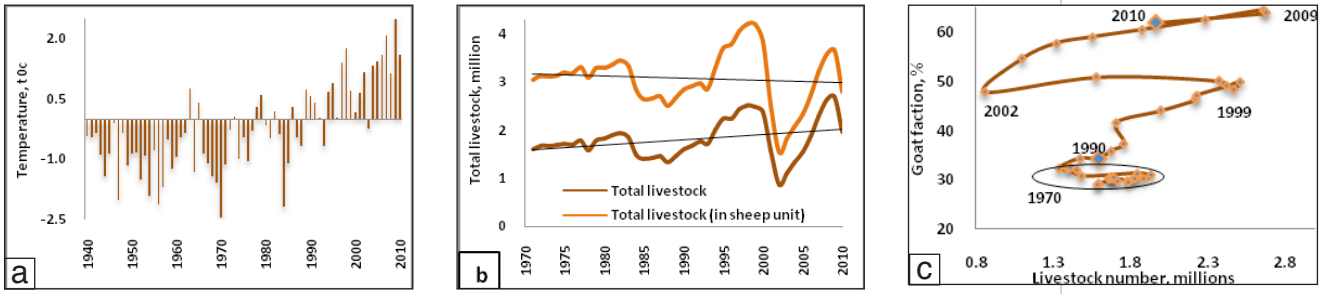

Figure 2. (a) Annual temperature anomaly, (b) livestock dynamics and (c) goat fraction change relative to livestock number in Bayanhongor aimag

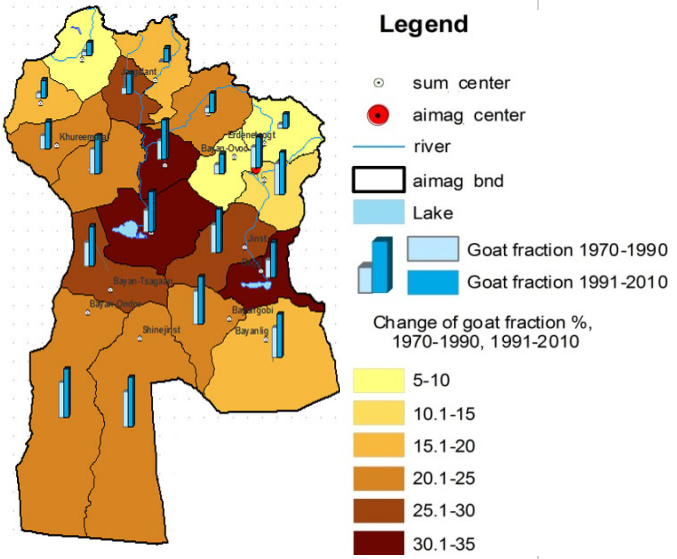

Figure 3. Change of goat fraction in the total livestock

during which livestock numbers also became more dynamic (Figure 2(b)) and livestock numbers increased by about 30% after privatization. Drought summers and *zuds* from 1999–2002 caused huge livestock losses, from which recovery took five to six years. The summer drought in 2009 followed by a *zud* in winter 2010 resulted in more than 300,000 livestock losses in Bayanhongor aimag (Statistical office of Bayanhongor aimag). Thus, both climate and market factors thus play an important role in livestock dynamics. The proportion of goats (goat fraction) in the total livestock numbers was very stable (~30%) during the socialist period (1970–1990), but increased up to 45% by 1999 and 60% by 2010 (Figure 2(c)). The biggest increases in goat fraction occurred in our study areas (Figure 3).

Drought occurs more often in the desert-steppe region compared to the forest steppe and steppe regions (Figure 4). Ecological vulnerability, which accounts for both drought and stocking rate relative

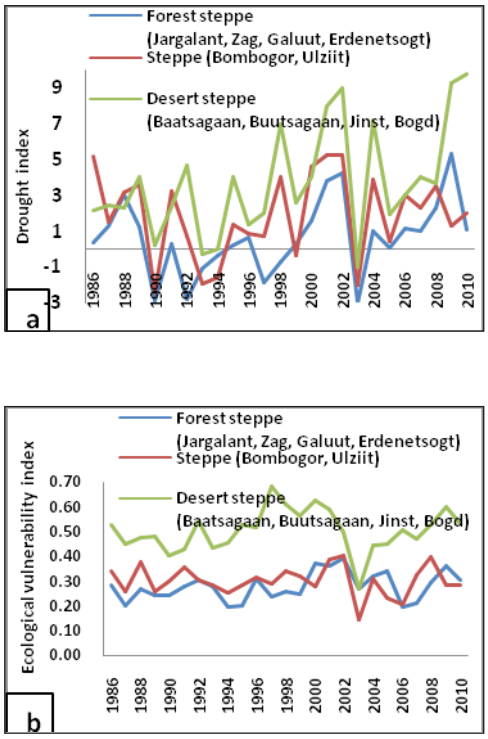

Figure 4. (a) drought and (b) ecological vulnerability assessment in the Tuin and Baidrag river basins by ecosystem type (1986–2010)

Principle	Pastoral social-ecological systems in Mongolia	Key implications for research, management and policy
P1: H-E systems are coupled, dynamic, and co-adapting, so that their structure, function, and interrelationships change over time.	Pastoral social-ecological systems (SESs) became more dynamic with goat number increases (due to income from cashmere) and *zud* impact on livestock loss, which have trade-offs for human or ecosystem well-being; Institutions became weaker compared with socialist period.	ki-1: A comprehensive research is needed for understanding changes in resilience of pastoral systems to climate change and market forcing; ki-2: Management of pastoral social-ecological systems require strategies to cope with global warming; ki-3: "Win-win" policy for both social and ecological resilience is needed;
P2: A limited suite of "slow" variables are critical determinants of H-E system dynamics.	Global warming is reducing forage and water resources overall and seasonally; Overgrazing increased with privatization of livestock.	ki-4: Water resource decrease due to global warming is key slow variable; ki-5: Spring season became bottleneck in short-grass steppe areas both due to drying and overgrazing;
P3: Thresholds in key slow variables define different states of H-E systems, often with different controlling processes; which may change over time.	Water resource decreases have crossed threshold level and are leading to collapse according to a survey. The Orog lake dried out in summer of 2009, but half filled in 2010; 3 out of 25 (as marked on a 1969 map) rivers and streams were flowing in 2009.	ki-6: Continued drying of many streams and lake water reduction indicate crossing of thresholds at different levels. Improved management in the remaining river basins and strengthening of "one-river" pastoral communities along these rivers are key to reduce vulnerability;
P4: Coupled H-E systems are hierarchical, nested, and networked across multiple scales.	Coupled *hot ails* embedded in streams, or small river communities embedded in larger river basin H-E systems are good examples of this.	ki-7: Integrated river basin social-ecological system management plans must be developed, which incorporate not only lower scales of coupled H-E systems, but aimag social-ecological systems;
P5: The maintenance of a body of up-to-date LEK is key to functional co-adaptation of H-E systems.	Local Environmental Knowledge (LEK), both traditional and scientific, is critical for adaptation. Many development projects may be mal-adaptive because of ignorance of traditional informal institutions, or knowledge on rangeland management, and culture.	ki-8: Identified knowledge gaps include: ~ Feedbacks; ~ Monitoring and forecasting of SES; ~ Prime examples of the best SESs based on hybrid scientific and traditional knowledge and innovation; ki-9: Diverse adaptive policies for different ecological-economic zones.

Table 1. Dryland Development Paradigm Application for the Tuin and Baidrag river basin social-ecological systems

to carrying capacity, is greater in the desert-steppe compared to the forest steppe and steppe regions (Figure 5a).

The social vulnerability of districts was calculated based on wealth (livestock number per capita), robustness (livestock loss during *zud* events from 1999–2002 and 2009–2010) and distance to the Bayanhongor aimag centre (Figure 5(b)). Social vulnerability is high when wealth and robustness are low, and distance to the market is long. Districts located in the desert-steppe zone have higher social vulnerability relative to districts located in forest steppe and steppe zones. Vulnerability of social-ecological systems in the desert-steppe zones is higher than in steppe and forest steppe zones (Figure 5c).

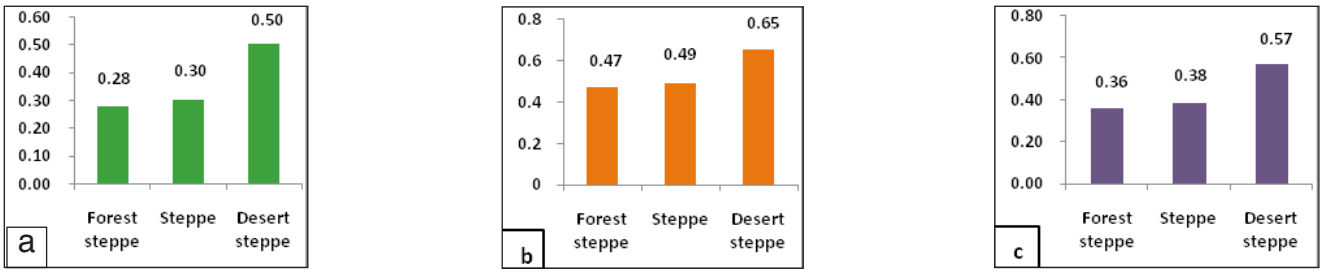

Figure 5. (a) Ecological, (b) social and (c) social-ecological vulnerability assessments in Tuin and Baidrag river basins by ecosystem type (1986–2010) (Forest steppe: Jargalant, Zag, Galuut, Erdenetsogt; Steppe: Bombogor, Ulziit; Desert steppe: Baatsagaan, Buutsagaan, Jinst, Bogd)

The main findings of our research are summarized in Table 1 (Chuluun *et al*. 2011).

Conclusion

Ecological vulnerability (drought, stocking rate relative to carrying capacity) and social vulnerability (livestock number per capita, distance to the market, livestock loss during *zud*) assessment trends showed that social-ecological vulnerability has increased in the desert-steppe region compared to other ecological zones in Mongolia. This indicates that the desert-steppe region is becoming more vulnerable to climate change, land-use change and transition in market economies. In coping with greater socio-ecological vulnerability due to both climate-related disasters and market forces in Mongolia, there is a greater need for adaptive policy regulation and innovative solutions.

These research findings and recommendations were used to develop a Tuin river basin sustainable management plan in collaboration with the Tuin River Basin Consul.

References

Chuluun, T., Altanbagana, M., Sarantuya, G. 2005. Vulnerability and adaptation assessment of the Mongolian pastoral systems to climate and land-use change. Proceedings of the Department of Biology, School of Natural Sciences, Mongolian Education University, 4: 182–189.

Chuluun, T., Ojima, D. 2011. Land in transition: Coping with market forces in managing rangelands in Mongolia. Pages 363–380 *In:* Roger E. Kasperson and Mimi Berberian (Ed.) Integrating Science and Policy: Vulnerability and Resilience in Global Environmental Change, Earthscan, London and Washington, DC.

Chuluun, T., Tserenchunt, B., Altanbagana, M., Stafford-Smith, M. 2011. Applying the Dryland Development Paradigm to pastoral systems in Mongolia. IRC, April 2–8, Rosario, Argentina, 690.

Davaa, G. 2009. Regime, resources, assessment and forecasting of surface water of Mongolia. Report of the Institute of Meteorology and Hydrology, Ulaanbaatar.

Natsagdorj, D., Sarantuya, G. 2004. On the Assessment and Forecasting of Winter Disaster (Atmospheric Caused Dzud) Over Mongolia — Sixth International Workshop Proceedings on Climate Change in Arid and Semi-Arid Regions of Asia, August 25–26, 2004. Ulaanbaatar, Mongolia, pp 72–88.

Ojima, D., Chuluun, T. 2008. Policy Changes in Mongolia: Implications for Land Use and Landscapes. pp 179–193 *In:* Galvin, K.A., Reid, R.S., Behnke, R.H. and Hobbs, N.T. (Eds.) Fragmentation in Semi-arid and Arid Landscapes: Consequences for Human and Natural Systems. Springer, Dordrecht, The Netherlands.

MARCC. 2009. MONGOLIA: Assessment Report on Climate Change. The Ministry of Nature, Environment and Tourism, UNEP and UNDP.

Ulaanbaatar, Mongolia. DDC 551.641 Y-594.
National Atlas of Mongolia. 1990. Mongolian Academy of Sciences. pp 144.
National Atlas of Mongolia. 2009. Institute of Geography, Ulaanbaatar. Published in Republic of Korea.
Statistical Office of Bayankhongor aimag. 2010. Statistical Yearbook-2010.
Reynolds, J.F., Stafford-Smith, M., Lambin, E.F., Turner, B.L. *et al.* 2007. Global Desertification: Building a Science for Dryland Development. Science 316: 847–851.

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COUNTRIES INVOLVED

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