



Exploratory analyses of local institutions for climate change adaptation in the Mongolian grasslands: An agent-based modeling approach



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ARTICLE INFO

Article history:

Received 11 October 2012

Received in revised form 8 July 2013

Accepted 20 July 2013

Keywords:

Social adaptation

Climate change

Local institutions

Agent-based modeling

Mongolian grasslands

ABSTRACT

There has been a decrease in grazing mobility in the Mongolian grasslands over the past decades. Sedentary grazing with substantial external inputs has increased the cost of livestock production. As a result, the livelihoods of herders have become more vulnerable to climate variability and change. Sedentary grazing is the formal institutional arrangement in Inner Mongolia, China. However, this may not be an efficient institutional arrangement for climate change adaptation. Self-organized local institutions for climate change adaptation have emerged and are under development in the study area. In this study, we did exploratory analyses of multiple local institutions for climate change adaptation in the Mongolian grasslands, using an agent-based modeling approach. Empirical studies from literature and our field work show that sedentary grazing, pasture rental markets, and reciprocal pasture-use groups are three popular institutional arrangements in the study area. First, we modeled the social–ecological performance (i.e., livelihood benefits to herders and grassland quality) of these institutions and their combinations under different climate conditions. Second, we did exploratory analyses of multiple social mechanisms for facilitating and maintaining cooperative use of pastures among herders. The modeling results show that in certain value-ranges of some model parameters with assumed values, reciprocal pasture-use groups had better performance than pasture rental markets; and the comparative advantage of cooperative use of pastures over sedentary grazing without cooperation becomes more evident with the increase in drought probability. Agent diversity and social norms were effective for facilitating the development of reciprocal pasture-use groups. Kin selection and punishments on free-riders were useful for maintaining cooperation among herders.

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1. Introduction

In the semiarid and arid grasslands of the world, such as Africa and Inner Asia (i.e., Southern Russia, Mongolia, and Northern China), seasonal and interannual migrations used to be the dominant livestock management strategies of herders to live with the highly variable climate. Flexible property boundaries, reciprocal use of pastures, and underlying social networks allowed herders to use pastures efficiently and to survive in the regions with frequent climate hazards (Fernandez-Giménez and Le Febvre, 2006; Humphrey and Sneath, 1999; Mwangi, 2007). Those institutions have evolved over centuries and are well suited to the biophysical characteristics of the local grassland ecosystems.

Over the past decades, social-institutions in those traditional grazing societies have changed dramatically, and the traditional communal pastures have been privatizing to individual households (Humphrey and Sneath, 1999; Mwangi, 2007). The local governments of those societies anticipated that private ownership could create incentives for herders to adopt better pasture-use practices, which could consequently improve pasture-use efficiency and livelihood benefits to herders (Mwangi, 2007; Williams, 2002; Zhang, 2007). With social-institutional changes in recent decades, there has been a decrease in grazing mobility in the traditional grazing systems of Africa and Inner Asia (Humphrey and Sneath, 1999; Mwangi, 2007; Sneath, 1998).

In this study, we focus on the grazing systems on the Mongolian plateau, including Mongolia and the Inner Mongolia Autonomous Region, China. Mongolia and Inner Mongolia experienced privatization in the early 1990s and mid-1980s, respectively (Li and Li, 2012; Sneath, 1998). In Mongolia, pastures are managed under a combination of customary rights and formal-use rights (Upton, 2009). Mobile grazing is still the

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dominant livestock management strategy in Mongolia. However, the distances and frequencies of seasonal and interannual migrations have decreased (Olonbayar, 2010). Because of the retreatment of governmental investments after economic reforms, herders with limited household endowments tend to migrate less frequently or to be sedentary grazing (Humphrey and Sneath, 1999). In Inner Mongolia, most pastures have been contracted to individual households and fenced, which is known as “household production responsibility systems (HPRS) (Li et al., 2007; Williams, 2002; Zhang, 2007).” Livestock grazing in most parts of Inner Mongolia has been sedentarized. Along with grazing sedentarization, the social norms of reciprocal use of pastures that the traditional nomadism was relied on have been disappearing (Li and Huntsinger, 2011; Upton, 2009). Besides social-institutional changes, climate change and pasture degradation have been evident on the Mongolian plateau over the past 50 years. Since the early 1960s, climate on the Mongolian plateau has been getting warmer and drier (Wang et al., 2013). The frequencies of climate hazards in Mongolia have increased, and they have caused disastrous effects on livestock production over the past 30 years (Fernandez-Giménez et al., 2012; Vernooy, 2011). Large-scale ecological surveys show that the average grassland biomass productivity in Inner Mongolia and Mongolia both has decreased about 50% over the past 50 years (IMIGSD, 2011; IOB, Mongolia, 2011). Decreased grazing mobility, climate change, and pasture degradation have increased livelihood vulnerability of herder communities in the Mongolian grasslands.

Social adaptation is the responses to risks and environmental stressors (Agrawal, 2009; O'Brien et al., 2004; Smit and Wandel, 2006; Wilbanks and Kates, 2010). In the context of multiple stressors discussed above, social adaptation has become increasingly important for livelihood sustainability of herder communities in the Mongolian grasslands. Studies have found that local institutions play the key role in shaping livelihood adaptation of rural communities to climate change (Agrawal, 2010). Agrawal (2010) argued that local institutions shape the impact of climate change on rural communities and the way they respond to climate change. Institutions, including formal and informal rules, are humanly devised constraints that shape human interactions and reduce social uncertainties (North, 1990; Ostrom, 1990). In the analytical framework focused on adaptation, institutions, and livelihoods (AIL), Agrawal classified local institutions into three major types: governmental/public institutions, market/private institutions, and communal/civic institutions (Agrawal, 2009). Previous studies have contributed to the understanding of social adaptation to climate variability and change on the Mongolian plateau (Fernandez-Giménez et al., 2012; Li and Huntsinger, 2011; Vernooy, 2011; Wang, 2013). Most of the previous studies focused on analyzing livelihood adaptation strategies of herders to climate change. Comparative studies of multiple local institutions for climate change adaptation in the Mongolian grasslands are still missing.

In this work, we focus on exploratory analyses of multiple local institutions for climate change adaptation in the semiarid and arid Mongolian grasslands with highly variable climate. We aim to answer the following question: what are efficient institutional arrangements that can improve social–ecological outcomes (i.e., livelihood benefits to herders and grassland quality) of pasture-use in the context of climate change? For example, sedentary grazing is the formal institutional arrangement in the grassland areas of China. However, this may not be an efficient institutional arrangement for climate change adaptation in the semiarid and arid grassland areas with highly variable climate. We hypothesized that in grassland areas with highly variable climate, the institutional arrangements that could facilitate cooperative use of pastures could generate better

social–ecological performance (i.e., livelihood benefits to herders and grassland quality) than sedentary grazing without cooperation. First, we did exploratory analyses of the social–ecological performance of multiple local institutions under different climate conditions, using an agent-based modeling platform. Second, we ran computational experiments to analyze multiple social mechanisms for facilitating and maintaining cooperative use of pastures among herders for climate change adaptation. Agent-based modeling is a useful tool for dynamically examining social processes and their interactions involved in multiple institutional arrangements.

Agent-based modeling is a promising quantitative methodology for social science research (Axerold, 1997; Epstein, 2007; Epstein and Axtell, 1997; Miller and Page, 2007). Agent-based models are process-based models that can be used to explain empirical phenomena, to help design and choose institutions, and to generate scenarios of agent actions and interactions. Agent heterogeneity, learning and adaptation, and social interactions can be easily included in the computational models. In the field of natural resource and environmental studies, agent-based models have been used in modeling urban sprawl and ecological effects (Brown et al., 2008), deforestation, reforestation, and ecological conservations (An et al., 2005; Chen et al., 2012; Manson and Evans, 2007), pasture dynamics and management (Bell, 2011), environmental migrations (Kniveton et al., 2011), and the institutions for sustainable governance of natural resources (Bravo, 2011; Deadman et al., 2000; Janssen and Ostrom, 2006). The decision-making process of agents (e.g., land users and managers) and agent interactions can be explicitly included in the models. Although agent-based models are effective tools for exploring different scenarios of human–environment interactions, they should be built on social theories that can explain agent actions and interactions.

The development of local institutions for climate change adaptation usually involves collective action of local people. The free-rider problem is an innate problem of collective action. The existence of free-riders affects the maintenance of cooperation. For example, in a pasture-use group where herders pool their pastures for communal grazing, some herders may overgraze communal pastures to increase their own benefits, and some herders may not let other herders access their pastures. The free-rider problem can cause the collapse of collective action. In this work, we did exploratory analyses of multiple social mechanisms for maintaining cooperative pasture-use groups among herders using an agent-based modeling platform. Over the past decades, several social mechanisms have been identified for solving the free-rider problem in collective action. The first mechanism is to keep the size of a cooperation group small, which is also known as “small-scale collective action (Olson, 1965).” The organization cost of cooperation increases with the increase in the size of a cooperation group. Communication and monitoring become difficult when the size of a cooperation group is large. Kinship is an important mechanism for maintaining cooperation (Nowak, 2006). Kinship can lower the organization cost of cooperation by making communication and trust easier. The third mechanism is the rights of free entry and exit of a cooperation group, which is also known as “voluntary games (Nowak, 2006).” If agents cannot benefit from being in a cooperation group and they cannot afford the exit cost of leaving a cooperation group, free-riding will be the dominant strategy for the agents. Otherwise, the rights of free entry and exit create “threats” for members in a cooperation group who plan to turn into free-riders. Punishing free-riders, which is also known as negative selective incentives (Nowak, 2006; Olson, 1982), is another important mechanism for maintaining cooperation. Punishment creates a cost to free-riders in collective action.

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