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Comparison of social-ecological resilience between two grassland management patterns driven by grassland land contract policy in the Maqu, Qinghai-Tibetan Plateau

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ABSTRACT

Embraced for decision-making, resilience has evolved as a meaningful term in areas such as ecology, the economy and society. After a policy of grassland contracts was implemented on the Qinghai-Tibetan Plateau, two grassland management patterns evolved: the multi-household management pattern (MMP) and the single-household management pattern (SMP). Within a resilience-driven perspective, this study compared the outcomes of these grassland management patterns by measuring their effects on the resilience of grazing, ecological, economic and social systems. Resilience indicators for each of the four systems were: grazing system (grazing space, transhumance, water source and reproduction); ecological system (vegetation including cover, biomass, species richness and soil properties including pH, organic carbon, total nitrogen and total phosphorus); economic system (income, expenditure and infrastructure) and the social system (health, assistance, social relations, cultural inheritance and institutional arrangements). In order to provide a social-ecological resilience framework for the two grassland management patterns, a decision support tool was applied to approximately gauge the resilience of each indicator. The results showed that each of the four systems under the MMP had a greater degree of resilience than the SMP, and that the overall resilience of the MMP was estimated at 5.8 units compared to about −5.8 units for the SMP. The relative success of the MMP was seen to rest largely on the maintenance of traditional management practices, social networks, trust and the low cost and high efficiency of informal institutions, which acted to reduce the risk of unsustainable development of ecological and social systems. The important take-home lesson from this study is that contracting of grasslands to private entities on the Qinghai-Tibetan Plateau, and in the rest of the world where similar land management practices exist, must be undertaken with caution.

1. Introduction

The term 'resilience', pioneered by Holling (1973), refers to the propensity of a natural system to retain its organizational structure and to continue to be reasonably productive following a significant perturbation, or the varied rate of return of a variable after such a perturbation is applied to the system (Vogel et al., 2012). Contextualized as a self-organizational process, resilience is meant to include the interaction between different structures and physical processes, leading to the evolution and development of the system regardless of the initial conditions (Gunderson, 2000). Although the definition of resilience adopted by professionals working in conservation, policy and the sciences has expanded (Brown and Williams, 2015; Carpenter et al., 2001; Ciftcioglu, 2017; Fisichelli et al., 2016; Oliver et al., 2015a), most of the resilience-driven thinking used as a guiding framework for addressing sustainability challenges tends to start with the premise that the social

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and ecological aspects are not identifiably separate (Cumming et al., 2005; Rist et al., 2014). Using resilience-thinking, multiple, cross-scale interactions, ecological thresholds and feedbacks in a social-ecological system (SES) are likely to be better understood, allowing resource managers and policy makers to maintain the flexibility necessary to respond to uncertainty and change (Cumming et al., 2005; Miller et al., 2010; Nelson et al., 2007; Plummer and Armitage, 2007).

In ecological sciences as applied in the present research paper, resilience refers to the ability of a multi-stable system to absorb different magnitudes of perturbations in order to resist ‘regime shifts’ and retain their functions and structure post-stress while maintaining the systems’ development (Bengtsson et al., 2003; Gallopín, 2006; Nelson et al., 2007; Ng et al., 2015). Ecological resilience is evolving into a credible paradigm for sustainable policy development, particularly for better environmental management to help preserve natural capital in a rapidly globalizing world (Spears et al., 2015). The diversity of species and their specific responses to the variation, heterogeneity, and redundancies and connectedness of habitats, as well as governance and management plans are known to influence the resilience of an ecosystem (Ayala-Orozco et al., 2016; Bengtsson et al., 2003; Cutter et al., 2008; Nyström et al., 2000; Oliver et al., 2015b; Sara and Nico, 2015). In the social sciences, resilience is often applied to describe the ability of groups or communities to buffer disturbances, and consequently, to self-organize, learn and adapt despite the existence of adversity emanating from social, political and environmental changes (Luthar and Cicchetti, 2000). An ability to learn through trust and engagement are thus the cornerstones of social resilience (Gunderson, 2000; Lebel et al., 2006). Good social relationships (*e.g.*, networks and individuals and groups in communities), and improvements in the awareness of risk, disaster management plans, insurance coverage, information sharing, local environmental knowledge and skills and access to resources are also relevant for enhancing the resilience of a given society (Berkes and Jolly, 2000; Cutter et al., 2008; Olsson et al., 2004; Paton et al., 2001; Tompkins and Adger, 2004). In the field of inter-disciplinary sciences, resilience is used to emphasize the functioning of an SES that involves inter-linked or coupled systems of people and nature, vital to the health of ecosystems, human wellbeing and resource equitability for current and future generations (Ciftcioglu, 2017; Nelson et al., 2007; Walker et al., 2002; 2006;). A resilient SES is thus likely to continually moderate and consequently adapt, while remaining within a stable domain, because natural resource managers are able to learn and actively adapt relevant ecosystem management policies and act to prevent unsustainable and undesirable development trajectories (Folke et al., 2010; Olsson et al., 2004; Spears et al., 2015). A disturbance or a crisis can sometimes be regarded as an opportunity for novelty, innovation and development in a resilient SES (Folke, 2006; Folke et al., 2010). A few previous studies have attempted to identify the characteristics of resilient systems from a broad socioeconomic perspective (Oliver et al., 2015a), but the research on social–ecological resilience is still very much in an exploratory phase (Folke, 2006), and often evaluated independently by social scientists and ecologists (Cao et al., 2014a).

Human actions and nature form a tightly coupled system, so an appropriate degree of natural resource management is sometimes warranted to increase the resilience of an ecosystem to exogenous factors such as stress or disturbances (Chambers et al., 2014). This can also assist in the promotion of the overall well-being of humanity (Ayala-Orozco et al., 2016). A transformation of strategies to increase resilience from the conceptual stage to the implementation stage is rather difficult or even impossible in some circumstances, due to the mismatch across different disciplines and scales, and underlying field conditions. Therefore, surrogate resilience indicators can be defined and applied to the entire spectrum of SES (Carpenter et al., 2001; Fisichelli et al., 2016). Empirical applications of resilience theory can contribute to different policy and management perspectives by evaluating the potential consequences of different manipulations made by policy makers and natural resource managers (Cumming et al., 2005).

Many case studies on resilience, and especially in ecological sciences, provide examples of these applications including: coral reefs (Hughes et al., 2003; McCulloch et al., 2012; Mumby et al., 2007), pollinator communities (Sara and Nico, 2015), grasslands (Craine et al., 2013; Klimeš et al., 2013; Looy et al., 2016; Vogel et al., 2012), forests (Scull et al., 2016), conservation of biodiversity (Sgrò et al., 2011), and fauna (Knapp et al., 2005). In social sciences, studies have focused on the resilience of grasslands to institutional arrangements (Schermer et al., 2016), resilience of water resource management to government policy (Schlüter and Pahl-wostl, 2007), and the resilience of farmland to traditional land management knowledge (Assefa and Hans-Rudolf, 2016). In SES, studies have focused on the resilience of natural resources management (Tompkins and Adger, 2004) and agricultural systems (Ciftcioglu, 2017; Darnhofer, 2014) to climate change, and on the resilience of SES to coastal disasters (Adger et al., 2005). Efforts to measure and assess the resilience within these diverse fields have stimulated significant research interests applied through an array of qualitative and quantitative approaches (Quinlan et al., 2016).

However, in previous studies performed on the resilience of grassland systems, most of the research focused only on the effects of species richness (Kühsel and Blüthgen, 2015), mowing in different seasons (Klimeš et al., 2013), fire (Anderies et al., 2002), or management issues (*e.g.*, mowing frequency, fertilizer applications) (Vogel et al., 2012), and seldom considered the effects of variation in grassland management (such as the grazing space or transhumance) induced by policy on SES, such as grassland management modifications in Maqu, on the eastern Qinghai-Tibetan Plateau (QTP). Historically, the herders of Maqu engaged in transhumant pastoralism with yak and Tibetan sheep based on collective management, an apparently environmentally sustainable use of the land (Cao et al., 2011; Yan et al., 2005). However, in the 1990s grassland management in this region, as in other countries around the world, was changed significantly through a set of policies of grassland contracts (Cao et al., 2011; Harris, 2010; Veeck et al., 2015) due to the influence of socio-political circumstances (Andersen et al., 2014; Singh et al., 2013). Although all winter grasslands were required to be contracted to single-households, many of the herders were unwilling to operate in isolation because of their history of collective nomadism and dependence on the collective lifestyle (Cao et al., 2011). With the implementation of grassland contract policy, two grassland management patterns evolved: (1) a multi-household management pattern (MMP) where the grassland was jointly managed by two or more households without fences between the individual household pastures, and (2) a single-household management pattern (SMP) where grassland was managed by individual households with fences demarcating the ownership, and the scope and space of the available rangeland was also inadvertently reduced (Yeh and Gaerrang, 2011; YontenNyima, 2012). At present, most of the MMP households have summer and winter pastures, while most of the SMP households have only one pasture for year-round use (Cao et al., 2013), a practice that is consistent with the one operating in Jammu and Kashmir, Northern India (Singh et al., 2013). Stocking rates (i.e., number of sheep per ha) were the same for both MMP and SMP and were mandated, monitored and enforced by Grassland Supervisor Stations (Cao et al., 2011).

In this paper, our primary aim is to explore the influence of the above mentioned two different grassland management patterns on grazing, ecological, economic, and social resilience, and to determine which grassland management pattern can maintain higher resilience of local SES in Maqu County.

2. Materials and methods

2.1. Study area

Maqu County, in Gansu province (101°–102°E, 33°–34°N), is located on the eastern QTP and traverses the boundary of Qinghai and Sichuan provinces in China. Its altitude ranges from 2900 to 4000 m and annual