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Analysis of policy-making process in grassland management in China

（中国草地管理の政策決定過程に関する研究）

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Abstract

Recent years have seen a rise in public concern of grassland degradation in China, which was partly triggered by the 1990s sandstorms that blanketed the sky of Beijing. In response to this environmental problem, the central government issued the Grazing Ban policy in the early 2000s. Hardly being something new, this grassland policy is in fact a continuation of past and on-going projects that are aimed at transforming local communities and local grazing system. Those projects include the collectivization in the 1950s, privatization in the 1980s and sedentarization in 2000s. All these projects are characterized by a tendency to blame local communities for environmental degradation and an emphasis on the necessity to replace local traditional knowledge and practices with modern science and technologies.

Previous scholarly criticism of grasslands policies tend to focus solely on their social and environmental impacts, paying little attention to the underlying institutional structures that have given rise to and sustained the policies. To contribute to further discussion of these issues, this study endeavors to reveal the structural factors and political forces that have shaped and are continually shaping grassland management in China.

Analysis on the institutional structures brought to light historical power struggles between government agencies and among scientist groups. The dominance of the Ministry of Agriculture (MA) and the marginalization of the State Ethnic Affairs Commission (SEAC) in grassland management have led to the formation of grassland policies in favor of modernizing pastoralism. And the social network analysis of Chinese scientist community revealed the dominance of ecologists inside the scientist network, which have facilitated the prevalence of the overgrazing-causes-degradation narrative. Though ecological anthropologists questioned this environmental narrative, their capacity to challenge the authority of ecologists was circumscribed by their small group size, weak intra-group connection, and limited political affiliation.

This study reveals that without transforming institutional structure and the scientist community associated with it, changing policies at the surficial level is unlikely to bring any positive change. Understanding these structural factors is crucial for guiding future policy reform and fostering a better understanding of environmental problems and their solutions.

Contents

List of Figures

List of Tables

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Introduction

When we think of grassland management, the first question that comes into our mind is how important grasslands are. Grasslands are valued not only as a food source to human beings and livestock, but also for their ecosystem services in terms of wildlife habitat, water storage, genetic conservation, and aesthetic values. Grasslands also have other important functions, such as defending human settlement from desert encroachment (Wang et al. 2015) or acting as “carbon sinks” to mitigate global warming(Smith 2014). As important as they are in contributing to the wellbeing of human society, the values of grasslands are sometimes poorly appreciated. Under increasing natural and anthropogenic stresses, such as climate change, land conversion, and urbanization, many grasslands are in critical conditions.

In the case of China, more than 40% of the land is covered by grasslands (State Bureau of Environment Protection 2006). Climate change, population migration and agricultural expansion have long affected the distribution of grasslands (Ye and Fang 2013). Severe grassland degradation was noted by grassland ecologists in the 1980s (Wu and Loucks 1992), and recent years have seen a rise in public concern of this environmental problem, which was partly triggered by the 1990s sandstorms that

blanketed the sky of Beijing (Zhang 2012).

Although politicians and scientists all agree that grasslands are degrading, they cannot agree on the causes and solutions. This grassland debate has continued for more than three decades and no consensus has been reached. Despite conflicting views among various social groups, the central government decided to target overgrazing as the main driver of grassland degradation. A series of regulations have been implemented since the 2000s, including four major regulations—year-round or seasonal grazing bans, demarcation of fallow fields, rotation grazing and livestock confinement (Dong et al. 2007). Hardly being something new, this strengthened regulation of local grazing activities is in fact a continuation of past and on-going projects that are aimed at transforming grasslands and local grazing activities. These projects include the collectivization in the 1950s, privatization in the 1980s and sedentarization in 2000s (Yeh 2005, Wang et al. 2014). All these projects are characterized by a tendency to blame local communities for environmental degradation and an emphasize on modernization of local traditional knowledge and practices (Zhu 2007, Zhang 2008a, Li and Li 2012, Luo 2013).

Some researchers explain the Chinese government's drive to modernize local communities by referring to Han-Chinese traditional ideologies that regard nomadism/pastoralism as backward and unproductive (Lattimore 1962, Williams 2002). Chinese literati used to address nomads/pastoralists and their environment in disparaging terms; both land and people were perceived as savagery (Williams 2002 p. 65). Those unsettled people were being "stigmatized as a 'backward' people, 'too primitive' to take up Chinese agriculture" and "to be a nomad was a kind of social crime"(Lattimore 1962 p. 417). This way of thinking was further reinforced after 1949. Guided by Marxist political philosophy, the central government began to adopt an evolutionist view, which puts agricultural society at a higher stage of civilization than pastoral society (Williams 2002). For those scholars, this official disregard for nomadism/pastoralism has its deep root in the culturally-constructed disparity between agrarian versus nomadic/pastoral societies.

However, the more we look into the history of grassland management in China, the more skeptical we become of those explanations. Scholars who argue about the agrarian nature of the Chinese government actually create a static rather than dynamic portrayal of the Chinese society, failing to notice other social and political changes that have

fundamentally transformed the ways in which Chinese government manages natural resources, grasslands included. Since China opened its door to foreign countries and started the reform towards a market-oriented economy, traditional agrarian-based ideologies have been gradually replaced by a new set of ideologies centered on industrialization and modernization. It is against this historical background that the clash between the central government and nomadic/pastoralist communities (mainly ethnic groups) takes on a new form of struggle. As written by the Chinese anthropologist Xiaotong Fei in his book *Pluralistic Integration of Chinese Nation*, "China is now on the path of industrialization and modernization… during the transition from an agrarian country to an industrialized nation, some new social problems will rise up concerning the development of different ethnic groups"(1999, pp. 36–37).

Fei's insight into the shifting nature of the Chinese society in a new era of modern development invites us to rethink the tension between the central government and the nomadic/pastoralist communities. As China advances towards an industrialized society, modern science and technology play an increasingly important role in informing and guiding national policies. The integration of scientific knowledge into the making of public policy changes the nature of the conflicts between the governments and local

communities (Scott 1998). Scientific measures and findings are increasingly used by the government to justify its macro plan and local intervention (Mitchell 2002). Conventional interpretations of grassland policies based on the agriculture-pastoralism dichotomy fall short in explaining this new social dynamics driven by the combined force of science and the state power. Extensive transformation of nomadic/pastoralist communities can only be fully understood within a broader context of institutional change and the politics of knowledge production and utilization.

This study endeavors to unveil the sociopolitical processes that have shaped and is continually shaping the public understanding of grasslands, which in turn transforms the way the central government manages grassland resources and governs local communities. The institutional arrangement of grassland management and power dynamics inside the scientist community are revealed to have influenced the historical development of grassland policies.

A history review of grassland policies in China was conducted in Chapter 1. The central government issued a series of grazing bans to control the problem of overgrazing in the 2000s. These policies, together with past grassland policies, echo ideas from several

scientific theories and models, including the Hardin's "tragedy of the commons" and the Himalayan degradation studies. Though these theories and models have been proved to be questionable, the central government continues to use these scientific ideas and narratives to justify national policies of pastoral development and grassland conservation.

The underlying institutional arrangement of grassland management was analyzed in Chapter 2. An examination of official historical documents brought to light the historical power struggle between two major government agencies—the State Ethnic Affairs Commission (SEAC) and the Ministry of Agriculture (MA). Both agencies are held responsible for the governance of pastoral societies. Ideological clashes between the culture-oriented SEAC and the economic-oriented MA manifested themselves in terms of political debates on how to understand cultural differences between agricultural and pastoral societies. The marginalization of SEAC and the dominance of MA in the administration of pastoral development in the 1980s have eventually led the governments to abandon the claims of cultural uniqueness of pastoralism. From then on, the practices of traditional pastoralism were no longer seen as an essential part of local culture, but considered as the barriers to industrialization and modernization. And the

modern transformation of local communities has continued for more than three decades under the leadership of MA.

Chapter 3 focused on different scientist groups participating in the scientific debate of grassland degradation as well as their influence on political decision-making. Scholars have been debating about the causes of grassland degradation, have suggested different solutions, and have enjoyed different degrees of public attention and government support. Social network analysis was used to visualize and quantify this scientist community. It is discovered that the dominance of grassland ecologists in the scientist network led to the prevalence of the overgrazing-causes-degradation narrative. Though ecological anthropologists later questioned this environmental narrative, their capacity to challenge the authority of ecologists was circumscribed by their small group size, weak intra-group connection, and limited political affiliation. This power dynamics between the scholar groups have given rise to and helped sustain the biased grassland policies that blame local communities and their traditional practices for environmental problems. This Chinese network was then compared with its counterpart in the United States in Chapter 4 for revealing the underlying—institutional and structural—factors that may facilitate or hinder interdisciplinary interactions among environmental

scientists. The patterns of interdisciplinary interactions in the two countries were examined. The absence of a bridge group on the Chinese side was found to be one of the important structural factors that explain the limited interdisciplinary knowledge exchange.

After explaining the power struggles among scientists, Chapter 5 went on to examine local changes after the implementation of the Grazing Ban policy. A case study of two villages—a farming village and a semi-grazing village—in Inner Mongolia was conducted. The examination of the local communities helps us to gain a deeper understanding of current environmental problems; it also allows us to evaluate the impacts of current grassland policies from the perspectives of sustainable use of natural resources.

The two villages being studied have adopted different adaptive strategies to cope with climate change and the official grazing ban. These local adaptive strategies have led to an increase in irrigated farmlands and fodder trades between the two villages. Although proved effective at the current stage, these strategies may threaten regional sustainability in long terms because of their tendency to overuse underground water.

These findings raise questions about the suitability of the current policy framework envisaged by MA and the central government.

Previous studies on grasslands management tend to focus solely on the evaluation of grassland policies (e.g. Li and Li, 2012b; Wang, 2009; Yeh, 2005), paying little attention to the underlying institutional structure and scientific network that have given rise to and sustained those policies. If current grassland policies are problematic, the institutions and individual (officials and scholars) that have contributed to the formation of those policies cannot be exempted from scrutiny. Understanding these structural factors can be the first step toward creating an inclusive grassland management that not only appreciates the diversity of environmental knowledge(s) and practices, but also allows the participation of local communities in the design and implementation of grassland policies.

1. Historical review of grassland policies

1.1. Introduction

This chapter provides a history review of grassland policies in China—from collectivization in the 1950s, to privatization in the 1980s, and to sedentarization and grazing ban in the 2000s—together with a summary of scholarly criticism of those policies. The underlying assumptions of these policies are discussed in the context of the development of theories and models concerning environmental degradation—Hardin's "tragedy of the commons", Himalayan degradation studies, and discussions on indigenous knowledge and the politics of environmental knowledge. How are certain theories reflected in environmental policies? Which theories or models are rejected or dismissed by the governments? Bearing those questions in mind enables us to steer through the history of the development of grassland policies and to grasp the central logic that governs the making of national grassland policies.

1.2. Sand storms and grassland policies

The flying sands blanketed the sky of Beijing in the 1990s. Most of the sandstorms occurred in the early spring, "blowing from Inner Mongolia (especially Alxa and the eastern grasslands) and northern Hebei into Beijing and Tianjian, and as far as Japan

and the Koreas" (Brown et al. 2008 p. 44). These environmental events aroused an increasing public concern about the problem of grassland degradation in the northern part of China. Following the rising public attention, the central government quickly targeted overgrazing as the main driver of grassland degradation and announced the implementation of the Grazing Ban policy in the early 2000s, which includes four major regulations—year-round or seasonal grazing bans, demarcation of fallow fields, rotation grazing and livestock confinement (Dong et al. 2007). Following these regulations, farming communities are totally banned from grazing, whereas semi-grazing/grazing communities are required to refrain from grazing their livestock in early spring. Hardly being something new, this Grazing Ban policy is in fact an extension of the past and on-going policies that the central government enacted as part of its long-term plan to modernize nomadic/pastoralist communities, which includes collectivization in the 1950s, privatization in the 1980s and sedentarization in the 2000s.

Government intervention in grassland management and the transformation of local grazing systems started as early as the 1950s. During the period of collectivization, most lands and production materials were owned by communes. Production system was organized in a hierarchical way—from "duguilong (several households grouped into

single production and consumption unites)", to production teams, to brigades, and to the township collective (Williams 2002). Because of Lack of work incentive, the productivity of this production system was extremely low (Li and Huntsinger 2011).The correction of the collectivization policies led to the dismantling of the communes and the introduction of Household Responsibility System (HRS) in the 1980s. Lands, livestock and production materials were redistributed to households, which has profoundly transformed social relationship in local communities since then (Goldstein 1997, Yeh 2003).

The sedentarization of nomadic/pastoralist communities was first initiated in Tibet in 2001 and later promoted among other autonomous regions and provinces. Those sedentarization projects "have been implemented as a development strategy in pastoral areas in an attempt to solve ecological and social problems. Subsidized by the government, these projects are intended to improve the pastoralists' standard of living by building houses, providing services such as tap water and electricity, and encouraging them to enter other professions"(Fan et al. 2014). Sedentarizing local communities is considered to be one of the preconditions for the development of modern pastoralism. Its "merits" are articulated in the *Plan for the National-wide*

Sedentarization of Nomads (2012): (1) reducing poverty (2) establishing modernized pastoralism (3) protecting grassland ecosystem (4) improving social stability of ethnic regions (National Development and Reform Commission 2012 pp. 9–10).

From collectivization to sedentarization, all the grassland policies share similar discourses that regard local tradition as backwardness, unproductive and environmentally destructive. Chinese government argues that local communities are often narrow minded and self-interest driven and stresses the importance of government intervention in economic development and environmental conservation. Modern pastoralism is promoted as the solution to both poverty and environmental degradation: traditional communes are replaced with household-based production units, transhumance is replaced sedentary, intensive pastoralism, and indigenous breeds are replaced with exotic breeds (Zhang 2008a, Li and Li 2012, Luo 2013).

1.3. Controversial policies and scholarly criticism

Though in official discourses, local communities and their traditional practices are held responsible for grassland degradation, many scholars remain skeptical about these claims. Local grassland problems are increasingly seen by scholars as the combined

result of climate change, government intervention and local activities(Cao et al. 2013). Moreover, many studies have raised concerns on the negative environmental consequences of the past grassland policies (Williams 2002, Yeh 2003, Wang 2009, Li and Li 2012).

The academic focus is first laid on the environmental impact during the collectivization era. During the 1950s, livestock production and grassland were collectivized. The communes not only organized production activities but also competed with each other to meet economic goals set by the central government. The local production competition had led to a sharp increase in livestock. During this period, "increased output of livestock products was taken as the only goal of livestock husbandry in pastoral areas, and this was connected with political discourse in the form of goals such as supporting the national economy and serving the people of the whole country (Li and Li 2012 p. 5). The expansion of livestock numbers during this era is believed to have resulted in increased grazing press on the local grasslands (Humphrey and Sneath 1999).

The collectivization era also witnessed the implementation of livestock breed improvement program, which was advocated as part of pastoral modernization. "Various

levels of government introduced a variety of rams of sheep breeds that produced fine and semi-fine wool and of Karakul sheep to hybridize with local breeds through artificial insemination"(Li and Li 2012 p. 6). Those new breeds were produced to support domestic production and foreign export. However, different from indigenous species, exotic breeds cannot adapt to local environment very well and are always in need of extra care and fodder. Causing the problem of labor and fodder shortage, the changes in livestock composition has left the local production system out of balance, which has in turn led to the increasingly dependence of local communities on external inputs (Li and Li 2012).

More changes occurred after the implementation of Household Responsibility System in the 1980s, whose impacts has lasted till today. Many scholars argue that the privatization has made the tension between livestock production and natural environment more acute than before (Williams 2002, Li and Huntsinger 2011, Wang et al. 2014). Traditional communal life allows herders to access various grass resources at a larger geographical scale; the subdivision of the commons, however, has limited livestock mobility and the flexible use of grassland resources. The privatization of grasslands and the subsequent land-fencing have compromise the flexibility of

traditional grazing practices, “resulting in a tragedy of rangeland deterioration and impoverished households” (Li and Huntsinger 2011 p. 11).

Other problems associated with the privatization are also noted. Williams points out the decline of animal husbandry expertise:

> “During the collective era, key households were selected to manage segregated livestock for the entire collective. Roughly forty herding households lived out on the rangeland and specialized in the care of a single animal type. Different animals have different grazing habits, so efficient management generally requires species segregation. Though the herders never received any special training to go along with their responsibilities to the collective, they did eventually acquire specialized knowledge and skills. With rangeland parcelization and a decline in the lianhu system of labor cooperation, however, routine chores of herd management have increasingly become the responsibility of each independent household. As a consequence, herding expertise has been diluted, mixed species typically graze together, and some critical rangeland management techniques (such as rotational grazing) have regressed to the lowest common denominator” (Williams 2002 p.

152)

Local herders also blamed policies of privatization and fencing for grassland degradation:

> "According to the herders……the degradation of pastures should be associated with the grassland fencing policies, which forced them to abuse the grassland by letting flocks graze uninterruptedly in territories that were too small. Before the fencing of the grasslands, problems such as pasture overcrowding and overgrazing did not occur. Therefore, according to the herders, they are not responsible for current degradation problems because they were just obeying Chinse government orders" (Cencetti 2011 p. 44).

Grassland privatization has caused the fragmentation of grassland resources, and intensified grazing pressure within the fenced grassland parcels. Each household has to think hard to sustain its livestock within its own rangeland boundaries. This tendency toward individuality and self-reliance was further reinforced by the Grazing Ban policy, as argued by Yu and Farrell (2013) in their recent study on 12 pastoralist villages in

northern China. They noted that the implementation of the Grazing Ban has caused a shift in local herding behavior towards a more individualized management that considers only short-term economic interests, suggesting that the policy-induced changes might threaten the regional sustainability in long terms (Yu and Farrell 2013). Local resistance to the Grazing Ban is another serious problem. Some studies point out that the government fails to gain local understanding and support, and that local villagers in certain regions circumvented the restriction by letting animals to forage at night (Sjögersten et al. 2013).

Indicated by the grazing ban, the government tends to assume that overgrazing is the main cause of grassland degradation. However, some scholars point out that the official overgrazing claim is actually based on a shaky scientific ground. Official evaluation of grassland condition is rarely subjected to scientific examination (Harris 2010). In national statistical survey, local agencies are required to classify grasslands into four basic categories—"non-degraded, or lightly, moderately, or heavily degraded". Without standardized definitions and without well-trained survey staff, "local grassland bureaus" are inclined to classify "areas under their jurisdiction based on superficial and subjective impressions" (Harris 2010 p. 3). Because of these statistical flaws, any evaluation or

modeling of grassland conditions based on the national survey data is fundamentally problematic. The lack of substantial statistical data also raised the question of the validity of the overgrazing claim.

1.4. Persistence of controversial policies

Besides examining the history of grassland policies, we should not forget another important fact that the problem of grassland degradation in China unfolds amidst a broader context—that is the international discussions of environmental degradation. Blaming local communities for environmental degradation is commonly observed in countries and regions other than China (Dove 2006, Weisiger and Cronon 2011), and this way of framing environmental degradation comes from several different branches of theories and models.

1.4.1. Hardin's "tragedy of the commons"

The Chinese government's self-criticism of the collective era co-occurred with the development of the tragedy-of-the-commons environmental discourse in the 1970s and 1980s, which argued that common resources may face the risk of depletion if individuals are allowed to act on their self-interests (Hardin 1968). Land privatization

was considered as a remedy to this environmental dilemma. Later Hardin's theory proved to be limited by other researchers (McKean 1982, Ostrom 1990). Ostrom pointed out that the free-rider and excludability problems of the commons that arguably contribute to the so-called tragedy of the commons are "affected by a host of variables including group size, heterogeneity of interests and various characteristics of the resource" (Araral 2014 p. 12). Inspired by Ostrom's research, many scholars devote their studies to explore and understand a wide range of factors that may affect the management of the commons, and more policymakers and project managers start to appreciate the diversity of the social institutions that support the utilization of common resources.

Thanks to the endeavors of Ostrom and other scholars, the theory of "the tragedy of the commons" has been widely reexamined. However, this academic shift did not change the official understanding in China. The Chinese government continues to advance its plan of land privatization and downplay the social functions of the communes in managing lands and other resources. Some natural scientists continue to use the theory of Hardin to interpret their research findings(Wang 1995, Yu et al. 1996). The basic assumption shared among Chinese policymakers and some researcher groups is that a

lack of clearly-defined property right system leads to exploitative behaviors in grasslands, such as overgrazing (Banks 2001). Only when individuals are entitled to pieces of grasslands will they start to prioritize long-term investment in improving their own grasslands over short-term economic gain.

1.4.2. Studies on Himalayan environmental degradation

Beside the theory of "tragedy of the commons", another branch of thinking has also influenced the formation of environmental discourse in China—that is the studies on Himalayan environmental degradation. Based on the past experience of Nepal, this group of scholars tends to explain environmental degradation as the result of farming on marginal lands. It is argued that demographic changes and the development of market economy created the problem of land shortage in the lowland and drove local people to farm on the marginal lands, which in turn led to soil erosion and other associated environmental problems (Forsyth 1996). One quotation from (Eckholm, 1976, p. 77; cited from Forsyth, 1996) illustrates the environmental discussions at the time:

> "Population growth in the context of a traditional agrarian technology is forcing farmers onto even steeper slopes, slopes unfit for sustained farming even with the

> astonishingly elaborate terracing practiced there. Meanwhile, villagers must roam further and further form their houses to gather fodder and firewood, thus surrounding villages with a widening circle of denuded hillsides."

This way of portraying local environmental history was soon challenged. Studies reveal that local communities actually developed agrarian technology to reduce soil erosion and that the Himalayan environmental crisis is more of a western construction that reflects the concerns of the west (Bjønness 1986, Forsyth 1996) than the local reality. The implicit relationship between poverty and environmental degradation in the Himalayan environmental narrative was also questioned. Opposed to the argument that small-farmers were responsible for land degradation in certain areas (e.g. Southgate, 1988), scholars argued that it was unclear whether poverty in general could force people into environmentally-destructive activities (Grepperud 1997), and that poor farmers were also willing to forgo short-term benefits for the sake of long-term sustainable development (Mortimore 1989). All these studies have helped to transform the widespread conviction that it is the local communities, especially the poor, that threatened the fragile environment.

The Chinese government's environmental claim bears great resemblance to the early-stage discussion on Himalayan environmental degradation, which held local communities, especially the poor, responsible for environmental destruction. And the linkage between poverty and environmental degradation has often been implied in official reports and discussions. For example, in the Plan for the National-wide Sedentarization of Nomads (2012), reducing poverty and protecting grasslands are both mentioned as the goals of the sedentarization project (National Development and Reform Commission, 2012, pp. 9–10). Till today, these underlying assumptions have been left unchanged, even though the international discussions of environmental degradation have gone through several rounds of rectifications.

1.4.3. Discussions on indigenous knowledge

Another change of the international discussion of environmental management lies in the reassertion of local communities as the potential stewards of nature. Studies in different fields and in different regions call for the due respect to indigenous knowledge and the proper application of local knowledge and practices in environmental management (Forsyth 1996, Klooster 2002, Yang 2015).

Conventional conservation approaches tended to separate people from nature and to view local communities as potential destroyers. Many projects were designed to protect areas of interest from human disturbance; even if the residency inside certain protected areas was allowed, the activities of the communities are very much limited (Borrini et al. 2004). But the understanding of environmental conservation gradually evolved to accommodate the social needs of people. Scholars emphasize that people and nature are fundamentally interlinked and that the environmental knowledge of indigenous communities can contribute to the well-being of ecosystems (Stevens 1997, Mauro and Hardison 2000). The importance of integrating indigenous and scientific knowledge is argued from three different perspectives: 1) indigenous knowledge is indispensable for maintaining cultural diversity at the age of globalization; 2) indigenous knowledge helps uncover some natural phenomena that might be otherwise ignored by modern scientists; 3) the inclusion of local communities in environmental management is an important part of social justice (Bohensky and Maru 2011).

However, the integration of local knowledge into environmental management has encountered many problems, and there are many barriers lying between local communities and scientists (Bohensky and Maru 2011). First, the unequal relations

between local people and the government prevents an effective communication and gives rise to plans that serve more the interests of the government and scientists (Nadasdy 1999). Regarding knowledge production, ontologies and methodologies used by scientists are essentially distinct from those of indigenous knowledge holders, which makes the two knowledge systems incommensurable (Verran 2001). Furthermore, improper integration sometimes leads to undesirable consequences (Fox et al. 2005). As long as the power relations and ontological differences still exist, building a comprehensive framework to make good use of indigenous knowledge remains a difficult task (Bohensky and Maru 2011, Bohensky et al. 2013).

This international discussion on indigenous knowledge since the 1990s seems to leave no impact on grassland management in China. Discussion on the important role of local communities, nomadic and pastoral communities included, in environmental management is somehow missing in the process of political decision-making. In the *Plan for the National-wide Sedentarization of Nomads*, the argument stops at the conclusion that local communities still suffered from poverty and low productivity (National Development and Reform Commission 2012). There is no discussion of the merits of traditional pastoralism and the potential contribution of local communities to

environmental conservation, not to mention the necessity to incorporate indigenous knowledge and practices into national plans. On the contrary, traditional pastoralism is held responsible for economic backwardness and environmental degradation, and is deemed to be replaced with scientific knowledge and modern technologies.

An increasing use of science and technology in monitoring grassland conditions contributes to the widening knowledge gap between the government and local communities. Officially, there are two way of monitoring the conditions of the grasslands. One is through fieldworks on the ground by ecologists, who establish observation stations and sample grass species in designated areas. Those surveys and observations follow a clearly-defined procedure, leaving no room for the communities' version of reality. Their focus on gathering ecological data leads to a limited contact with local communities, not to mention a deep engagement with local knowledge and practices. They are "experts", but also "outsider" in the eyes of local communities (Williams 2002). Another approach is to gain a large-scale understanding of the grasslands through the analysis of satellite images. Although ground data are sampled for reference purpose, there is usually no mention of local communities and accounts of local activities are reduced to statistical data from provincial/national yearbooks.

The alienation from local communities is reinforced when the governments increasingly depend on the remote sensing images to talk about macro-scale landscape transformation (Rajão 2013). Large-scale studies with conflicting findings often make it difficult to draw conclusions about the on-going environmental changes at local level. It remains questionable to what extent the visual presentation of environmental changes made available by remote sensing analysis reflects real conditions at a local scale (Rasmussen et al. 2015). Despite the fact that remote sensing data may not fully reflect the truth on the ground, the satellite-based presentation of environmental problems have replaced local accounts to become part of the discourse of policy-makers (Fairhead and Leach 1998, Rajão 2013). This is the reason why remote sensing analysis have been criticized by social scientists for its misuse as a scientific tool to justify top-down policymaking while marginalize local knowledge in the practices of environmental management and conservation (Scott 1996, Rajão 2013).

1.4.4. Divide between natural and social sciences

Western science has long been criticized for its dualistic organization of academic research, which draws a distinction between nature and culture and subsequently

separates natural sciences from social sciences. When it comes to the study of human-nature relations, this rigid intellectual divide renders it difficult for scientists from both sides to break through their conceptual straightjacket and communicate in common terms. The impact of this disciplinary divide on environmental management attracts the attention of many scholars. Strang (2009) examines interdisciplinary collaboration in water management in Australia and lists all the possible factors that can prevent an effective interdisciplinary collaboration. These factors include 1) the nature-culture dualism, 2) specialization of research approaches, 3) other factors, such as funding disparity and political influence. He emphasizes that interdisciplinary collaboration in a real sense requires not only an integration of theoretical frameworks but also an egalitarian participation of scientists in the process of political decision-making.

Chinese government's biased environmental policies are also influenced by this ingrained dualism that characterized Western science, and at the same time this academic dichotomy helps conceal the falsehood of these policies, as pointed out by Williams (2002, p. 78):

"The invisibility of such cultural bias makes it easy for the Western scientist to be

unaware that alternative representations of nature even exist in Inner Mongolia. The structure of engagement with local data generally compels them to endorse rather than challenge the Chinese discourse concerning the causes and culprits of land degradation and the policies considered necessary to control them. I witnessed this process in operation, as the research station hosted many international delegations during my year of residency. I was astonished that delegation upon delegation verbally endorsed the Han perspective and the full range of national grassland policies by the time they left the research station".

The lack of interdisciplinary collaboration has led to the exclusion of social factors in the discussion of grassland ecosystems (Loucks and Wu 1992, p.80, cited by Williams, 2002). The conceptual barrier between natural and social sciences has not only limited the advance of scientific understanding on grasslands, but also exerted a profound influence on official attitudes towards local communities and their traditional knowledge.

1.5. Conclusion

The central government strengthened its regulation over grazing activities after a series of sandstorms, which gave rise to the Grazing Ban policy in the early 2000s. This

Grazing Ban policy, like previous grassland policies and programs, continues to blame local communities for environmental degradation and stress the importance of modernizing pastoralism. These policies and official environmental discourses have developed in the historical context of international discussions of environmental degradation, and have received influence from the ideas of Hardin's "tragedy of the commons" and the early-stage Himalayan degradation theories. Despite the facts that the international discussions of environmental changes have gone through several ideological shifts and that the integration of local communities into environmental management is deemed increasingly important, grassland policies and official discourses in China remain relatively unchanged. The persistence of biased environmental policies and discourses—in other words, the political inertia—requires explanations. In the following chapters, the political processes that have sustained these policies will be analyzed, with Chapter 2 focusing on the institutional arrangement and Chapter 3 on power struggles inside the scientist community.

2. Institutional and ideological transformations

2.1. Introduction

This chapter analyzed the underlying institutional arrangement of grassland management. A review of official historical documents was conducted to identify key agencies that have influenced the making of grassland policies and to trace their changing authorities inside the administrative system. This analysis brought to light the historical power struggle between two major agencies—the State Ethnic Affairs Commission (SEAC) and the Ministry of Agriculture (MA). Political discussions in official documents on how to understand traditional pastoralism and cultural differences between agricultural and pastoral societies provided valuable clues to the ideological clashes between the two institutions between the 1950s and 1970s. Parallel to the rise to dominance of MA in grassland management in the 1980s, we witness an increasing advocacy of modern pastoralism on the government side.

2.2. Institutional struggles between MA and SEAC

In China, grasslands are managed by many institutions, which includes the Ministry of Agriculture (MA), the State Forestry Administration (SFA), the Ministry of Environmental Protection (MEP), the Ministry of Water Resources (MWR) and the Ministry of Civil Affairs (MCA) (Brown et al. 2008, Li et al. 2014). Among all the

institutions, MA is the major institution that takes charge of comprehensive grassland management. It is composed of 19 administrative bureaus, among which the Animal Husbandry Bureau administers the regulations of grazing activities and the protection of grasslands (Brown et al. 2008). Though assigned the responsibility and authority, the institutional capacity of the MA to manage pastoral activities is often undermined by its tendency to impose agriculture-centered policies (Williams 2002) and by its emphasis on livestock production rather than grassland conservation (Zhang 2012).

Back in the 1950s, there was another institution that had played an equally important role in the administration of nomadic/pastoral regions—that is the State Ethnic Affairs Commission (SEAC). Its current functions and responsibilities, described on the official website[1], are implementing national ethnic policies, conducting ethnic studies and coordinating ethnic affairs with other socioeconomic activities. According to this official description, the role of SEAC is more of a coordinator than a policy designer and implementer. However, a close examination of official historical documents reveals that it was directly involved in the management of nomadism/pastoralism in the 1950s. In the guidelines of SEAC's Third Extended Meeting, its managerial goals were

[1] http://www.seac.gov.cn/col/col2/index.html. Accessed on November 19, 2015.

described as “carrying out cautious intervention and facilitating stable progress” and “revitalizing animal husbandry production”(People’s Publishing House 1958 pp. 100–112). In 1957, the central government approved two important official plans. They are MA’s *Guidelines on Developing Animal Husbandry* and SEAC’s decision on socialist reform at nomadic regions—*Principles on Socialist Reform of Nomadism*. This indicates that SEAC once played a more important role than it does now.

As the main issuers of national grassland policies, both SEAC and MA had taken charge of grassland management and pastoral development. However, there was something very special about SEAC that extinguished it from MA as well as other government institutions. Unlike other bureaus that were set up according to sector divisions (such as the Ministry of Agriculture, the Ministry of Heavy Industry, and etc.), SEAC were concerned with all the aspects related to ethnic regions (including pastoral regions) and had taken a holistic perspective towards ethnic affairs (including pastoral development) since its establishment. Moreover, being sensitive to cultural differences, it paid special attention to socioeconomic characteristics of ethnic regions, as argued in the following statement:

> "In all our works, [we] have to sufficiently take into account the specific characteristics and conditions of each ethnic group. The social condition of each group is extremely complicated in terms of politics, economics, culture, religious belief and customs and habits. They are not only different from Han Chinese but also different from each other……[Therefore] we should not mechanically replicate policies implemented in Han Chinese regions to ethnic regions. Nor should we transfer policies between different ethnic regions"(People's Publishing House 1958 p. 103).

In this statement, SEAC called for the design of national policies based on a careful consideration of political, economic and cultural characteristics of ethnic regions. Its holistic perspective and cultural sensitivity counterbalanced the economic-centered approach of the sector-centered institutions such as MA or MHI. Instead of limiting its focus to economic development, SEAC emphasized the importance of including "culture, religious belief and customs and habits" in the discussion of ethnic affairs. By pointing out the differences between Han Chinese and ethnic regions, SEAC stressed the need to adapt national policies to local conditions rather than dogmatic imposition of a universal plan.

Thanks to cautious attitudes of SEAC, pastoral communities were shielded from massive social transformations that had swept across the nation during the early 1950s. Till 1957, attention to varying local conditions advocated by the SEAC could still be observed, and social reform plans that had been experimented in farming regions were postponed in pastoral regions:

> "Socialist reform will not carry out in the farming-grazing transitional zone. In order to prevent social disturbance in pastoralist societies by already-transformed farming communities nearby, [local governments] should stick to the principle of 'No Reform No Division, Herd Owners and Herders Gain Mutual Benefits'. [local governments] should promote livestock production in pastoral regions, and nomadism/pastoralism should be the main production sector in semi-agricultural and semi-nomadic zones, complemented by farming"(Central Party Literature Press 1993 p. 665).

However, a sudden change of political rhetoric during the late 1950s started to compromise the political stance of SEAC. It gradually became politically problematic to

claim that there are significant cultural differences between Han Chinese and ethnic groups. As exemplified in the discussion of Goodman in his case study of Guizhou province, the minority nationalities were criticized "for putting their nationalism before the country's unity, and for insisting that local customs should be stressed regardless of their merit" (1986: P59-60). And subsequent events such as Anti-Rightists Movement accelerated the progress of social transformation in ethnic regions (including pastoral regions).

Along with the compromised role of the SEAC and the changing attitude toward local cultural traditions were the increasing official stress on the importance of agricultural production, which in turn changes the power balance between MA and SEAC. From the late 1950s, because of the nation-wide promotion of agricultural production system centered on grain, farmlands were expanded. In the mid-1960s, several new national slogans were raised, calling for transforming grazing systems into farming systems (*Muqu xiang Nongqu Guodu*) as well as strengthening self-reliance of pastoral communities (*Mumin Buchi Kuixinliang*)[2]. This triggered a grand transformation of local landscape—large areas of high-quality grasslands were converted into farmlands.

[2] The two slogans in Chinese are "牧区向农区过渡"and"牧民不吃亏心粮".

All these social changes culminated at the final removal of SEAC in 1970[3]. The agency's administration over ethnic affairs was suspended until 1978. The eight-year absence of SEAC in the administrative system had led to a decrease in the number of officials and intellectuals working on local traditions and practices. At the meantime, the power of MA had been strengthened thanks to the national emphasis over agricultural production. More power was invested in MA to promote agriculture. The decline and final absence of SEAC in the administrative system has led to a loss of alternative perspective, alternative sets of understandings and political ideologies, and more importantly, alternatives policies as responses to social problems.

When SEAC was reestablished, it could hardly resume its previous power. What kind of role did SEAC play at the aftermath of Cultural Revolution and the beginning of new era of Reform and Opening? In *Outlines for National Working Conference on Nomadic Regions* issued in 1987, it was made clear that MA (at that time the Ministry of Agriculture, Pastoralism and Fisheries), rather than SEAC, is the main agency administering grassland management and pastoral development:

[3] Dates of institutional changes can be referred to http://www.seac.gov.cn/col/col2/index.html. Accessed on November 19, 2015.

> "In order to enhance and coordinate the economic administration of nomadic regions, the conference decided that the Ministry of Agriculture, Pastoralism and Fisheries [later changed into MA] will be the leading institution, collaborating with SEAC, supported by other bureaus, to conduct researches on and carry out economic development plans of nomadic regions, to lead, supervise and check the implementation and fiscal condition of guidelines and policies concerned with pastoral regions."

This official statement clarified the leading role of MA in administering pastoral regions. After going through the political turmoil between 1950s and 1970s, SEAC had been reestablished and resumed its power in the 1980s, but only serving as a supplementary agency to MA in the administration of pastoralism.

The years between the 1960s and 1970s were a transition period for SEAC. In 1957, each of the two institutions issued one official instruction on pastoralism—MA issued the *Instructions on Promoting Pastoral Production* and SEAC issued the *Instructions on Socialist Transformation of Pastoralism*. This illustrates that both agencies have the

administrative authority over pastoral regions at that time. However, because of the shifting of political rhetoric in 1957 and institutional adjustment in 1970, the political capacity of SEAC was significantly weakened in comparison with MA. During the eight-year absence, SEAC lost not only its official records and documents but also political and intellectual base. It could only partially resume its administrative power after its reestablishment in 1978. The downward movement of SEAC in the official hierarchy is made clear in 1987, when the central government declared that MA is the leading institution that takes charge of pastoralism.

During the political turmoil between the 1950s and 1970s, not only SEAC got suspended, so was its intellectual base, which included the discipline of anthropology and other related social sciences. Many intellectuals focusing on ethnic groups were forced to leave their position in research institutions or universities and to participate in production activities in rural areas. This periodical suspension of academic activities is reflected in the edition and publication of the Five-series Books on Ethnic Affairs (*Minzu Wenti Wutao Congshu*). Led by SEAC, the compilation of these books was initiated in 1958, interrupted during Cultural Revolution, resumed in 1978 and finally finished in 1991. In other words, during this historical period, even though national

policies bent on transforming pastoral regions proceeded without interruption, the academic efforts to understand pastoral societies were abruptly intercepted.

2.3. Ideological transformation and "Grass Industry"

2.3.1. Rediscovering pastoralism

Institutional restructuring is only part of the historical processes that have transformed grassland management. The restructuring of institutional relations is followed by changes in political ideologies that have further reinforced the power of MA in comparison with SEAC. Ideological shifts, together with new scientific theories on pastoralism, have allowed MA to redraw the blueprint of pastoral development and embark on the path of modernization. There were two major ideological changes that have affected MA's understanding of pastoralism in the following decades. One is the reemphasis on the economic importance of pastoralism, and the other is the emergence of the theory of "grass industry"(*Cao Chanye*) (Li 2010).

Since the establishment of People's Republic of China, food security is always at the top of national agenda. And food, in Chinese perception, refers to grain rather than meat, and it is believed that it is the farming communities that feed the whole nation and keep

people from starving. Therefore grazing communities were seen as parasites and needed to be transformed into, if not totally farming societies, at least subsistence communities. Those biased ideas fed to maliciously spread rumors and were politically manipulated during Cultural Revolution. The slogan "Nomads Do Not Eat Unethical Grain" (*Mumin buchi Kuixinliang*) was raised up and pastoralists/nomads were encouraged to grow crops in their own grasslands. The cultural legacy of this social turmoil is a series of biased associations, which related nomads with parasites, grass with weed, and grasslands with wastelands.

To correct the past political mistakes and remove the social stigma that was once imposed on pastoralism, in the late 1970s and the early 1980s, the central government started to claim that pastoralism is as economically important as agriculture and utilizing grasslands is as meaningful as growing crops. These changes are observed in the speeches of several senior officials. Deng Xiaoping commented that "Planting grass is much easier than planting trees, and planting grass could prevent soil erosion, support livestock, generate more income than farming, and provide meat products. Inner Mongolia, Xingjiang and Qinghai that used to be high-income nomadic regions have

suffered losses in the past [because of agriculture-centered policies]"[4]. Hu Yaobang, during his visit to Ganshu Province in 1983, indicated that planting grass and trees and developing pastoralism is the key to poverty reduction[5].

From these comments, we can tell that the government started to shift away from its agriculture-centered policies and recognize pastoralism as an important part of national economy. But in official discourses, there was another ideological twist. That is instead of making effective use of natural grasslands, planting grass was raised as one of the crucial aspects of pastoralism. This official emphasis on grass plantation instead of native grasslands blurred differences between agrarian and pastoral systems. Grasslands were treated in the same way as crop fields that are subject to human manipulation. These changes indicate that, following the declining of SEAC, a new set of managerial ideology started to dominate official rhetoric.

Besides the emphasis on "planting grass", there was also a shift in official discourse

[4] See the Comments of Deng Xiaoping on Grass Plantation and Pastoral Development on August 9th, 1979 in "Official opinions on grass plantation and grassland construction since the Third Plenum of the 11th Central Committee of the Communist Party of China" (1984), Pratacultural Science1(4):1.

[5] See the Comments of Hu Yaobang in Fieldtrip to Gansu on August 3rd, 1983 in "Official opinions on grass plantation and grassland construction since the Third Plenum of the 11th Central Committee of the Communist Party of China" (1984), Pratacultural Science1(4):3-4.

toward “productivity” and “efficiency”, which can be discerned in Zhao Ziyang’s talk during his trip to Qinghai:

> “It is said that in the Qinghai region every year the fodder is in short supply for about four or five months. This situation is worth studying. Considering the growing number of livestock, grasslands cannot grow well, which in turn affects the productivity of pastoralism. Grasslands that could not fatten the livestock could be regarded as a waste of resources….This is a rather serious problem. How to increase the productivity of grasslands is a very important research topic.” (1983)[6]

In his comments, the value of grasslands was closely associated with its economic function of fattening livestock. This simplified way of evaluating grasslands has deprived grasslands of their cultural and ecological value. The subtle balance between local fauna and animals (including livestock) in local ecosystem is reduced into a matter of “productivity”. This economic simplification, as many social scientists have criticized, eventually erased all the cultural distinctiveness of pastoralism (Yeh 2005, Li

[6] See the Comments of Zhao Ziyang in Fieldtrip to Qinghai in July, 1983 in “Official opinions on grass plantation and grassland construction since the Third Plenum of the 11th Central Committee of the Communist Party of China” (1984), Pratacultural Science1(4):4.

and Li 2012, Zhang 2012). Out of the revived focus on pastoralism in the 1980s, a new managerial framework took shape. Grasslands have been taken away from their cultural contexts, but instead increasingly treated in the way as farmlands whose productivity can be controlled by human beings. These new discussions in the early 1980s have portrayed pastoralism as a new engine of national economy, which holds the same productive potential as farmlands.

2.3.2. Emergence of the Theory of "Grass Industry"

Parallel to the reevaluation of grassland in terms of productivity, a new theory on engineering grasslands gradually came into shape. This is another ideological change that has shaped the path of grassland management in China. In 1984, Qian Xuesen wrote an article for Inner Mongolia Daily, titled "Grass, Grass Industry and New Technological Revolution"[7]. He drew some similarities between grass plantation and crop/tree plantation, arguing that the fundamental biological mechanism of grasslands is the same with that of agriculture or forestry, because all of these eco-systems are basically about converting solar energy into carbohydrate. He suggested, like modern agriculture, the main task of what he called grass industry was to convert solar energy

[7] See Qian, X. (1984, June 28). Grass, Grass Industry and New Technological Revolution (Caoyuan Caoye he Xinjishu Geming). *Inner Mongolia Daily*.

more efficiently into food or other products that could be consumed by society.

To further illustrate his points, Qian gave a detailed description of a grass-based industrial model:

> "How can we use modern science and technology to develop grass industry? First, we have to plant grass….which requires careful seed selection and effective protection of planted lands against natural disasters…to enable grasslands to produce high-quality, high-nutrition fodder. For intensive pastoralism, we need to pay attention to how to manufacture fodder out of grass. The tricky part of building up concentrated livestock husbandry lies in the utilization and treatment of animal waste…We need to treat waste as resources… using biotechnology and comprehensive industrial processing to produce valuable products, which includes cultivating mushrooms, raising earthworms, biogas fermentation, fishery and etc.. In the very end, the final wastes and residues could be returned to grasslands as fertilizer. In this production cycle, mushrooms and fish are already end products, whereas earthworms can be sent to fodder manufacturers and used as protein additives. As to biogas, it can be used as fuel for cooking, automobile as well as

electricity generation."[8]

This industrial model raised by Qian is not so much different from the present-day model of cyclic economy. Qian was trying to create a sound, cyclic industrial system based on grass resources in response to the official promotion of pastoral development. Later he extended his Systems-Engineering theories to agriculture, forestry, and fishery, calling them knowledge-intensive agrarian industry(Qian 1985). In all the subfields, the main theme remained the same. It evolves around the question of how to effectively establish a chain of enterprises which mimicked the ecosystem and could facilitate the process of converting solar energy to carbohydrate, wastes to resources and eventually return residues to ecosystems.

Qian is a preeminent scientist and engineer. His credibility mainly came from his unique political status as "Father of China's Space Program". He had studied in the United States and was one of the founders of the Jet Propulsion Laboratory at the California Institution of Technology[9]. Later he returned to China and became one of the leading

[8] See Qian, X. S. (1984, June 28). Grass, Grass Industry and New Technological Revolution (Caoyuan Caoye he Xinjishu Geming). *Inner Mongolia Daily*.
[9] See Noland, C. (2009, November 1). "Qian Xuesen dies at 98; rocket scientist helped establish Jet Propulsion Laboratory". *Los Angeles Times*.

scientists in the national space program. All these honors had added to his theory an undisputable power of conviction. However, he was neither an ecologist nor a fieldwork-oriented environmental scientist. What renders his industrial system model problematic is the fact that the model did not include some factors or elements that could potentially influence the productivity of grasslands such as climate, water accessibility, indigenous flora and fauna, and local livelihoods.

The controversial role of Qian Xueshen in misguiding national policies has been discussed by some scholars. His indirect participation in the Great Leap Forward has been revealed. In the late 1950s, eager to demonstrate the supremacy of socialist regime, Chairman Mao declared that China could grow much faster and would overtake Britain in fifteen years. Experiments were conducted to demonstrate that the yield of a rice paddy could be significantly increased by planting rice seedlings more densely (Yang 2012). In June 1958, one county in Henan was reported to produce 1760 kilogram per mu (2.64 kilogram/square meters), which soon aroused public skepticism over the validity of the number. Against those public doubts, Qian, as one of the top scientists, wrote one article titled *How Much Rice One Mu Could Produce?*[10], explaining that it is

[10] See Qian, X. S. (1958, June 16). How Much Rice One Mu Could Produce? (Liangshi Muchanliang Hui You Duoshao). *China Youth Daily*.

the solar energy available on a plot of land that determines the upper limit of the amount of food could be produced. He argued that according to scientific calculations, the potential amount of grain production would be twenty times more if farmers devote enough efforts to farmlands in terms of both labor and technology. His writing convinced many officials, including Chairman Mao himself, that it is technologically possible to dramatically increase crop yield (Yang 2012). Yang (2012) argues that Qian's argument had to some extent served as a theoretical support to Mao's Great Leap Forward policy.

粮食亩产量会有多少？

錢学森

"前年卖粮用箩挑，去年卖粮用船摇；今年汽車装不下，明年火車还嫌小！"

这是江西井岡山农民的一首民歌。我們的土地正在农民双手豪迈的劳动中，付給人們更多的粮食。六月十二日中国青年报第一版上發表了一个动人的消息：河南省遂平县衛星农业社籬小麦亩产二千一百零五斤以后，又有二亩九分地平均每亩打下了三千五百三十斤小麦。

土地所能給人們的粮食产量碰頂了嗎？

科学的計算告訴人們：还远得很！今后，通过农民的創造和农业科学工作者的努力，将会大大突破今天的丰产成績。因为，农業生产的最終極限决定于每年单位面积上的太阳光能，如果把这个光能換算农产品，要比現在的丰产量高出很多。現在我們来算一算：把每年射到一亩地上的太阳光能的30%作为植物可以利用的部分，而植物利用这些太阳光能把空气里的二氧化碳和水分制造成自己的养料，供給自己發育、生长結实，再把其中的五分之一算是可吃的粮食，那么稻麦每年的亩产量就不仅仅是現在的两千多斤或三千多斤，而是两千多斤的20多倍！

这并不是空談。举一个例：今年河南有些特别丰产試驗田要在一亩地里收一百六十万斤蔬菜。虽說蔬菜不是粮食，但到底是亩产一百六十万斤！

所以，只要我們有必需的水利、肥料等等条件，加上人們的不断創造，产量的不断提高是沒有問題的。今天条件不具备，明天就会創造出来；今天还沒有，明天一定会有！

太阳：你把这些都吃掉，还能长大二十倍！

裘 桑画

Fig. 1. Article titled How Much Rice One Mu Could Produce?

Qian's scientific theory in the 1950s centered on solar energy proved to be a mere theoretical construction. However, almost 30 years later, he used the same

principle—that is solar energy determines productivity—to support national policies in grassland management. Despite his problematic role in Great Leap Forward, nobody questioned his authority to guide a new round of agrarian and pastoral reform. The phases in his paper, such as "grass industry", "technological revolution" and "knowledge-intensive industry" were frequently cited in other papers (e.g. Li, 2010). Since then, the principles of managing grassland started to converge with those of industrial agriculture. All the official aspirations of industrialization and modernization of the northern part of China are condensed into a single image of grasslands—a vast green landscape generated mainly by grass plantation and air seeding. Thanks to this new image, local pastoralism started to be evaluated against a set of industrial standards centered on productivity and efficiency.

The theory of "grass industry" just reinforced the social understanding of nomadism/pastoralism as something traditional, less civilized, and most importantly, less productive. The government argues that traditional pastoralism must be changed. Systematic reform is necessary to transform the old-fashioned system of managing grass into a more efficient, more productive one, which bears a resemblance to the social-evolution theory of Marxism that considers pastoralism as a primitive form of

society (Williams 2002). In *Outlines for National Conference on Pastoral Regions* (The State Council 1987), the first problem raised was the low productivity of traditional pastoralism:

> "Because of historical, social and environmental reasons, the majority of pastoral communities haven't left behind the nomadic/semi-nomadic way of living. There is no doubt that the fundamental way of developing pastoralism is to facilitate local transition from traditional pastoralism to modern pastoralism, from semi-subsistence/subsistence economy to massive production. We have to protect grasslands, prevent overgrazing, and guide local communities to change from nomadism to more intensive livestock husbandry, from an economy based on single sector to a diversified economy, from nomadism/ semi-nomadism to sedentarization/ semi-sedentarization".

This way of defining nomadism/pastoralism as backward, less productive and even environmental destructive has persisted till today and been used to justify the modern transformation of local communities, such as privatization and sedentarization. In the *Plan for the National-wide Sedentarization of Nomads* (National Development and

Reform Commission 2012), statistical numbers were used to prove the low productivity of traditional nomadism/pastoralism:

> "In 2009, underdeveloped regions have the rate of domestic big livestock for sale and the rate of sheep for sale per year at 27.7% and 59 % respectively, far below the national averages that are 43.5% and 95.2%. Though northern part of Xinjiang and the eastern part of Inner Mongolia have a relatively high turnover rate in sheep husbandry, there remains a gap between that of the underdeveloped regions and that of the national average. The nomadic way of livestock management results in severe species devolution……The traditional nomadism/pastoralism renders local economy vulnerable to natural hazards. Long-distance transregional grazing usually led to a higher livestock mortality rate. In June 2009, a heavy snow resulted in a loss of around 80,000 livestock in Naqu, Tibet. Thirdly, the average annual income of a nomad/pastoralist is much lower than that of a peasant. In 2009, the average annual income per person for pastoral region is 2724 RMB, which is only 52.9% of the earning in farming regions."

The government uses low productivity, low resilience to natural disaster, and low

income to characterize pastoralism. From the point view of the government, modernizing pastoralism not only brings about a more efficient way of utilizing resources, but also a sustainable way of managing grasslands. To facilitate the establishment of modern pastoralism, the government has carried out many projects, including the settling down of pastoral communities, privatization of grasslands, grass plantation and concentrated management of livestock and grasslands. Based on the modern criteria of productivity and efficiency, the government has continued its transformation of local tradition and production system till today.

2.4. Conclusion

Political and ideological reconstructing has erased the old discussion over cultural aspects of pastoralism, not to mention the possible merits of local knowledge in terms of grassland conservation. Though, after the social tumults of 60s and 70s, pastoralism has been resume its political importance and been considered as an integrative part of national economy, local communities and grasslands have gradually lost their social and cultural idiosyncrasy. Local tradition and social conditions are no longer used as an excuse to stop the matching wheel of modern transformation. On the contrary, the characteristics of pastoralism became the synonyms of backwardness and

under-development. In the hand of the MA, under the modern criteria of productivity and efficiency, local communities and grasslands have undergone many changes. The following chapter will go on to examine scientific debate on grassland degradation and to reveal how power struggles among scientist groups have influenced the formation of environmental discourses and the making of grassland policies.

3. Hidden power struggles inside scientist communities[11]

3.1. Introduction

This chapter aims to understand how the structure of the scientist community influences political decision-making. As discussed in Chapter 1 and 2, many grassland management policies have been implemented since 1950s, and these policies reflect similar ideological tendency that blames local communities for environmental degradation and economic backwardness and emphasizes replacement of local traditional knowledge and practices. However, political ideas alone are not sufficient for justifying political actions. These ideas have to be supported by scientific theories and evidences to attain convincing power over the public. This is where science and policy meet. "At the interface, knowledge is translated into usable knowledge, policy questions are translated into research questions, and knowledge translation and use take place as well"(Kasperson and Berberian 2011 p. 202). One of the examples of this dynamic interaction between science and policy comes from the climate change policies—the climate change debate originates from pure scientific research before the greenhouse effect "was perceived as a problem and entered the political agenda" (Davies 2012 p.

[11] This chapter is published in the journal Environmental Science and Policy. Refer to Li, A., and M. Sakamoto. 2015. Hidden scientist network behind environmental management—Case study of grassland management in China. Environmental Science and Policy 54:248–253.

110). In the case of grassland management in China, in order to understand how science and policy interact with one another, a close examination of the scientific debate of grassland degradation and the associated scientist community is necessary. This kind of analysis helps us to understand how much influence the scientist community has on the making of grassland policies.

Social network analysis was applied to visualize and quantify the scientist community. Both static and dynamic portrayals were used to provide a holistic view of the network in China until the year 2013. This work is followed by an in-depth interpretation of the network, drawing a parallel between the evolution of the scientist community and the development of national grassland policies.

3.2. Literature review: Scientific debate and scientist network

Policymakers always face multiple, if not conflicting, interpretations of social problems and constantly make choices among competing ideas and theories. This dilemma encountered by policymakers is caused partly by the uncertainty inherent in scientific studies (Bradshaw and Borchers, 2000; Donovan and Oppenheimer, 2014), and partly by power struggles among competing scientists who play advisory roles and are eager to extend their influence into the political domain (Blyth, 2002; Spruijt et al., 2014). A

certain model or explanation may be acknowledged by policymakers as valid and convincing, but its authority may soon be challenged by new emerging theories. It is well argued that the legitimacy of an idea is contingent on the authority of the scientist group as well as historical sociopolitical conditions (Crane, 1972; Kuhn, 1962). Considering all of the complexities in the science-policy interface, there is an increasing call for an open, transparent and flexible mechanism that can facilitate communication between scientists and policymakers.

The majority of studies on the science-policy interface tend to focus on the institutional divide that separates scientists and policymakers. The science-policy gap has been explained as the result of blocked communication, insufficient coordination or intentional dismissal by stakeholders. The flow of knowledge might be hindered by political actors holding different claims(Runhaar and van Nieuwaal, 2010), by inadequate coordination that might lead to a divergence of opinions between policymakers and research entities(Holmes and Clark, 2008), or research that insufficiently reflects the interests of stakeholders might be dismissed as untrustworthy or illegitimate (Diedrich et al., 2010; Turnhout et al., 2008; Van de Riet, 2003). With most research efforts devoted to studying barriers in the science-policy interface, the

question of how the internal structure of the scientist community influences outcomes in the science-policy interface remains unanswered. It has long been argued that the scientist community itself is a complicated institution in which scientists play different social roles—core members, gatekeepers, brokers, etc. (Jasanoff, 1987; Nursey-Bray et al., 2014; Runhaar and van Nieuwaal, 2010), but a closer examination of the structure of the scientist community is largely left out of the discussion.

The study of the internal structure of the scientist community is crucial for unveiling the uncertainty inherent in science because most of the time uncertainty among scientists is not publicly revealed. Sometimes scientists are reluctant to discuss openly how confident they are with their research results, concerned that the public may be unable to make sense of the revealed information (Donovan and Oppenheimer, 2014; Frewer and Miles, 2002). There may also be situations where a powerful scientist group that not only dominates scientist discourse but also suppresses oppositional voices and contradictory evidence. In this case, uncertainty may be obscured or even censured in public discussion. Therefore, in situations where scientists unintentionally or intentionally cover up the details of scientific uncertainty, the examination of the scientist community is necessary for conveying the inherent uncertainty in scientific

knowledge to policymakers and the public.

The need to study the internal structure of the scientist community also comes from the understanding that the engagement of different groups of scientists in the policy-making process is not always equal. The power of scientist groups varies greatly inside the scientist community, depending on size, position, structural characteristics and connections with other groups. Stronger groups may have a greater vocal presence in academic debates and thus have more control over the flow of information and the production of knowledge; they are also more likely to exert a greater sociopolitical impact on policymakers (Fischer, 2003; Van Dijk, 1997). Some attempts have been made in exploring power struggles inside the scientist community by applying discourse analysis (Buchanan, 2013; Nursey-Bray et al., 2014), but these analyses were conducted without understanding the structural characteristics of the scientist community.

Complementing these studies, the revelation of the internal structure of the scientist community may bring new insights into politics in the science-policy interface. In the following part, the structure of the scientist community and its implication on political decision-making in grassland management in China are discussed.

3.3. Data preparation and analysis

One way to portray the community is to draw connections among scientists based on citations (references and bibliographic data). It is argued that the flow of communication among scientists or disciplines is a function of the distribution of references among them (Pierce, 1999; Stirling, 2007). Porter and Chubin first developed this approach in 1985 for measuring interdisciplinarity. Similar approaches were used to examine the scientist community in both a specific discipline and the general science domain (Rinia et al., 2002; Steele and Stier, 2000). By using the same approach, this study visualizes the scientist community and identifies its structural characteristics in a quantitative way.

The key to this method of analysis lies in finding the appropriate target group. For this study, a number of scientists directly engaged in the discussion on grassland management were selected. Academic discussion of grassland management in China started around the 1980s and attracted public attention during the 1990s after several severe sandstorms hit Beijing. Many scientists devoted their studies to investigating the problem of grassland degradation, but could not agree on the cause. The debate has

continued for more than two decades and no consensus has been reached. The discussion among these scientists has shaped the environmental understanding of grassland problems and the subsequent political responses.

The China Knowledge Resource Integrated Database (CNKI), which covers publications of a wide range of disciplines in China, was selected as the source of bibliographic data. The selection of scientists and their papers was based on the approach of snowball sampling. Using this approach, one important scientist in the field of grassland management was selected as the starting point of the search. Scholars cited by the beginning scientist became the candidates for the next round of searching. Some scholars have raised the issue of possible bias introduced by the snowball sampling method (Atkinson and Flint, 2001; Illenberger and Flötteröd, 2012; Lee et al., 2006). The biases in sampling are believed to be almost negligible because this study focuses on scientists associated with grassland management, rather than the entire scientist community. To limit the sampling to major scholars, two criteria were applied: 1) the selected paper, either citing others or being referred to, must contain the key words “grassland destruction”, “grassland degradation”, or “grassland conservation”, and 2) the paper must be cited by more than three other papers to be regarded as academically

important.

In the social network analysis, scientists were abstracted as nodes, and their references to each other were modeled as directed links. Each scientist was assigned a disciplinary affiliation based on his/her academic background. The sampled community included scientists from eight discipline categories: 1) historical geography, 2) ecological anthropology, 3) grassland ecology, 4) grassland engineering, 5) institutional economics, 6) desertification, 7) climate change, and 8) others. In addition to disciplinary affiliation, political affiliations of the scientists were also recorded. Scientists with political affiliation were defined as scientists working in administrative institutions or in think tanks associated with government, whereas scientists with no political affiliation were defined as those working in universities and research institutes. Statistical details about the sampled scientists and their papers are listed in Table 1.

A static analysis of the scientist network was performed on the sample data. The degree of enclosedness of each group inside the network was measured using the E-I index. This index is defined as the number of inter-group links minus the number of intra-group links, normalized by the total number of links in the network. Values for the

E-I index range between 1 and -1, with the number 1 indicating complete openness of the group to other groups and the number -1 indicating complete enclosedness. Both the transformation of the data matrix and the calculation of the E-I index were performed using UCINET, a software package used for social network analysis. The final output is summarized in Table 2.

Table 1. Summary of sampled data

Disciplines	No. of Authors	pct.	No.of papers	pct.	No. of authors with political affiliation	pct.
Historical geography	13	9%	17	10%	1	2%
Ecological anthropology	45	32%	54	31%	6	12%
Grassland ecology	55	39%	64	37%	27	52%
Grassland engineering	3	2%	4	2%	3	6%
Institutional economics	14	10%	20	12%	7	13%
Desertification	6	4%	9	5%	6	12%
Climate change	3	2%	3	2%	1	2%
Others	2	1%	2	1%	1	2%
Total	141	100%	173	100%	52	100%

A dynamic analysis was conducted by mapping the historical evolution of the network

(see Fig. 2). The visualization was produced using Organization Risk Analyzer (Carley et al., 2013). The appearance of each scientist in the network was determined by the year of his or her earliest publication. The years 1990, 2000, 2005 and 2013 were selected as points of temporal reference. The network was initially mapped with an interval of 10 years, but due to the fact that many important changes occurred between 2000 and 2013, the authors decided to add 2005 as another historical referential point.

Table 2. E-I index by discipline

Disciplines	**No. of nodes**	**Internal links**	**External Links**	**Total links**	**E-I index**
Historical geography	13	34	15	49	-0.388
Ecological anthropology	45	146	48	194	-0.505
Grassland ecology	55	230	43	273	-0.685
Grassland engineering	3	2	11	13	0.692
Institutional economics	14	20	24	44	0.091
Desertification	6	12	9	21	-0.143
Climate change	2	0	3	3	1.000
Others	141	0	3	3	1.000

3.4. Results

The static analysis of the network reveals that the group of grassland ecologists is larger in size, and has more political affiliations and more intra-group ties. Inside the scientist community, grassland ecologists number 55, compared with 45 anthropologists who

constitute the second largest group in the network (see Table 1). Ecologists also tend to have more political affiliations—52% of the scientists with political affiliation are from the group of grassland ecology (see Table 1). A closer look at the political affiliation reveals that 11 ecologists are affiliated with the Ministry of Agriculture (MA), whereas four anthropologists are affiliated with the State Ethnic Affairs Commission (SEAC). Because MA and SEAC have different authorities in managing grasslands, this difference in institutional affiliation may result in different political impacts.

The E-I index illustrates both the internal structure of each group and interrelationships between groups (see Table 2). Two groups (ecological anthropologists and grassland ecologists) have larger negative E-I index values, indicating that the two groups have a higher degree of enclosedness. This means that scientists from the two disciplines compose two enclosed clusters and have a limited exchange of knowledge with other disciplines. Moreover, the absolute E-I index value of the ecologist group is larger than that of the anthropologist group, which suggests that the intra-group connection of ecologists is stronger. Scientist groups with high, positive E-I index values are grassland engineering and climate change, although these values may be the result of overestimation due to small sampling sizes of the two disciplines in the network (see

Table 1).

The evolving trajectory of the scientist network is made clear in Fig. 2. The total number of scientists increased from 22 in 1990 to 141 in 2013, and the interaction among scholars also intensified. The growing interaction among scientists could be inferred from two changes in the network: 1) the average degree (in-or out-degree) changed from 1.318 in 1990 to 2.830 in 2013 and 2) there were fewer scholars isolated from the main component of the network.

The dynamic portrayal of the network reveals the rise of the ecologist group inside the scientist community (see Fig. 2). Until 1990, there were mainly two groups—grassland ecologists (green) and historical geographers (red), with other scientists scattering around. By 2000, the cluster of ecologists became the dominant group in the network. Another two groups—ecological anthropologists (blue) and institutional economists (yellow)—joined the community between 2000 and 2005. The anthropologist group grew in the following decade and developed into the second largest cluster—a cluster of 45 scholars with 146 internal links. However, until 2013, the grassland-ecologist group remained the largest and the most connected group in the network (55 scholars with 230

internal links).

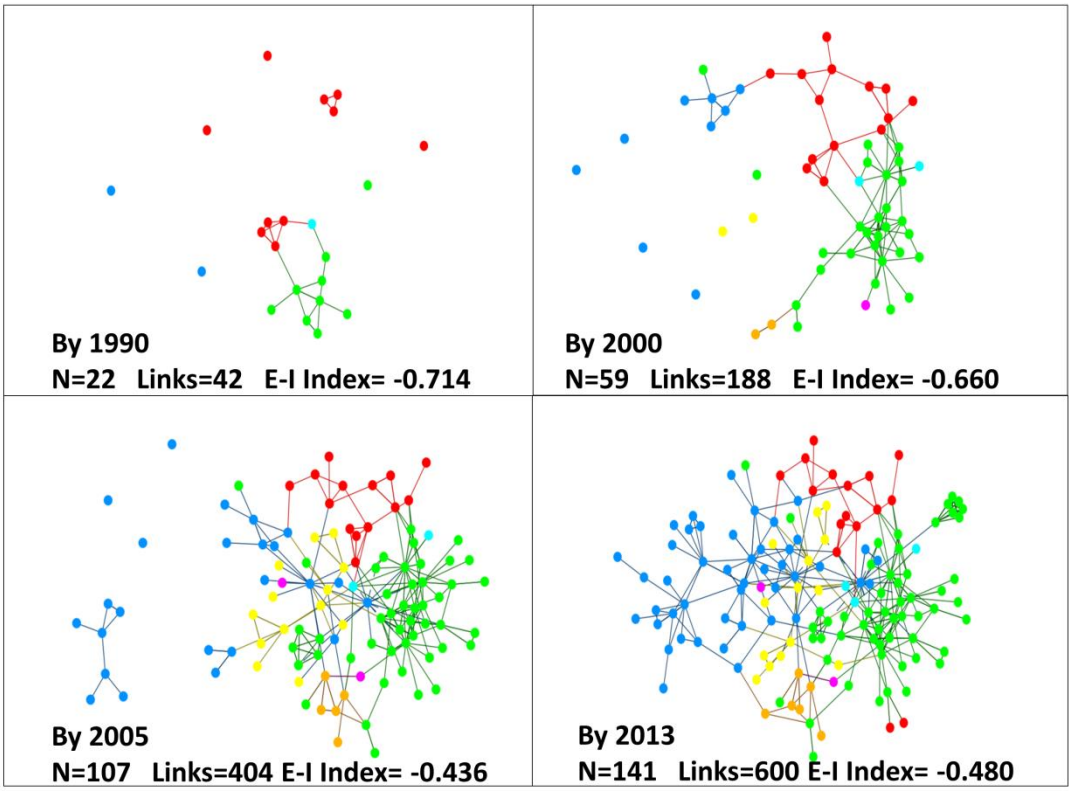

Fig. 2. Evolution of scientist community

The colors of major disciplines are: historical geography—red; grassland ecologist—green; ecological anthropology—blue; institutional economics—yellow.

3.5. Discussion

The social network analysis shows that a group of ecologists appeared in the network much earlier than those of other disciplines and remained the group that is larger in size, and has more political affiliations and more intra-group ties. These findings provide a basis for understanding the relationship between the structure of the scientist

community and the development of national grassland policies in China.

3.5.1. Development of environmental understanding

The understanding of grassland-degradation problems has co-evolved with the theoretical development of the component disciplines. The discipline of ecology developed and elaborated the theory of grassland management much earlier than other disciplines (Sampson, 1952; Wu and Loucks, 1992). The two decades between the 1960s and 1980s are regarded as one of the most important historical periods for the development of grassland ecology in China, during which many fundamental works—such as the creation of grassland classification systems—were completed (Wu and Loucks, 1992). Following the development of grassland classification, ecologists began to systematically evaluate grassland condition and describe the problem of grassland degradation (Wang, 1992; Wu and Loucks, 1992). This early engagement of ecologists in grassland studies is revealed in the previous social network analysis. As shown in Fig. 2, grassland ecologists, together with historical geographers, first emerged in the network.

Not only did ecologists assess the condition of grassland degradation, but they also

provided the first explanation about the root cause of the problem. It was argued that "overgrazing and overtreading have caused a decrease in the diversity of species and community structure" (Wu and Loucks, 1992: 75) and that "overgrazing encourages the propagation of poisonous grass and weeds", which again causes grassland degradation (Zhang, 1992: 118). The same argument was bolstered by remote sensing data (Chen and Li, 1987). The idea that overgrazing led to grassland degradation was almost unanimously shared by the ecologists sampled in the study. The explanation favored by ecologists gave rise to the first narrative of grassland degradation. Due to a lack of competing scholar groups (see Fig. 2), the explanation given by ecologists was widely accepted.

When another group—ecological anthropologists— joined the grassland discussion, the academic landscape started to change. Instead of blaming local communities for grassland degradation, anthropologists tended to emphasize the merits of indigenous knowledge and practices and their potential contribution to environmental conservation. However, the emergence of ecological anthropologists in the scientific debate was rather late. They first appeared between 2000 and 2005, and became the second largest group by 2013 (see Fig. 2).

The late appearance of anthropologists in the network can be explained by its late development in China. The earliest research base of ecological anthropology formed in the 1980s in Yunnan province, where historically a lot of ethnic minorities are located. A second center late emerged in the 1990s in Guizhou and Hunan Provinces (Yin 2012). Studies in the two research bases do not speak directly to grassland management. The significant meaning of the two research centers to grassland management lies in their emphasis on indigenous environmental knowledge. Some studies endeavor to unlock the underlying ecological rational for traditional production practices; some studies explore the possible contribution of indigenous knowledge to biodiversity and environmental conservation (Yin 2012). These studies provide theoretical reference and supportive case studies for later studies on cultures and traditions of pastoral society.

A third camp of ecological anthropologists is mainly based in the north of China. This is also where anthropologists directly engaged in grassland-conservation debate come from. Most scholars are from universities and research institutions geographically located around Beijing and Inner Mongolia (Yin 2012). The causes of grassland degradation raised by this group can be summarized into three categories: 1)

privatization, 2) sedentarization, and 3) loss of indigenous knowledge. It is argued privatization has changed original herding practices of local communities, fragmenting grassland resources, reducing the mobility of herds and leading to intensive grazing in very small areas (Zhang 2008b). Privatization has also weakened communal connections and reduced the opportunities of cooperation among households (Zhang 2008b). Regarding sedentarization, it has similar effects with privatization in terms of limiting the mobility of livestock. Both privatization and sedentarization have made it increasingly difficult for households to carry out the long-distance movement in times of natural disaster such as snowstorms, and have therefore increased the vulnerability of local communities in fact of environmental change (Se 1998, Xun 2011). These transformations of traditional herding patterns, communal relationships, and local adaptive strategies to the semi-arid/arid environment have led scholars to decry a loss of indigenous environmental knowledge (Erdenbuhe 2004, Zhang 2008b, Altanbaoleg 2011, Xun 2011, Menghewuliji 2013). Based on these discussions, anthropologists went further to argue that the transformation of local production system, rather than overgrazing, is the underlying mechanism behind the problems of overgrazing and grassland degradation (Zhang 2008a, Luo 2013). These domestic discussions of official grassland policies echo the criticism made by western scholars on land privatization and

official ignorance of indigenous knowledge (Ostrom 1990, Williams 2002, Yeh 2005, Dove 2006), which has been discussed in details in the Chapter 1. Gradually anthropologists have formed an important pole in the debate of grassland management and conservation, questioning the simplified and one-sided portray of grassland problems by ecologists.

Between the years 1990 and 2013, due to the participation of anthropology and other disciplines, the scientist community concerned with grassland management evolved into a larger network. The conflicting environmental understanding between ecologists and anthropologists led to an academic debate about grassland degradation, which added more complications and uncertainty to grassland management policies. However, the development of conflicting interpretations did not undermine the authority of the ecologist group, whose political influence remains strong. To understand this, the authors link the structure of the scientist community with the advancement of national grassland policies.

3.5.2. From environmental understanding to policy-making

The once-hidden relationship between the scientist community and policy-making

reveals itself when the evolution of the scientist network is compared with the historical chronology of national policies. The storyline of the science-policy interaction is portrayed in Fig. 3. The political influence of ecologists is closely associated with the timing of their rise to dominance in the network. Ecologists achieved their dominance by 2000. Around the same time, in response to several severe sandstorms that struck Beijing in the late 1990s and early 2000s (Sun et al., 2004; Zhang et al., 2005), the Chinese government initiated a new series of grassland policies. The environmental explanation of ecologists—overgrazing by local communities caused grassland degradation—was the theory that the government adopted and incorporated into national policies. Against this historical background, grassland ecologists quickly emerged as the leading scientist group either advising on or directly participating in the making of national grassland policies.

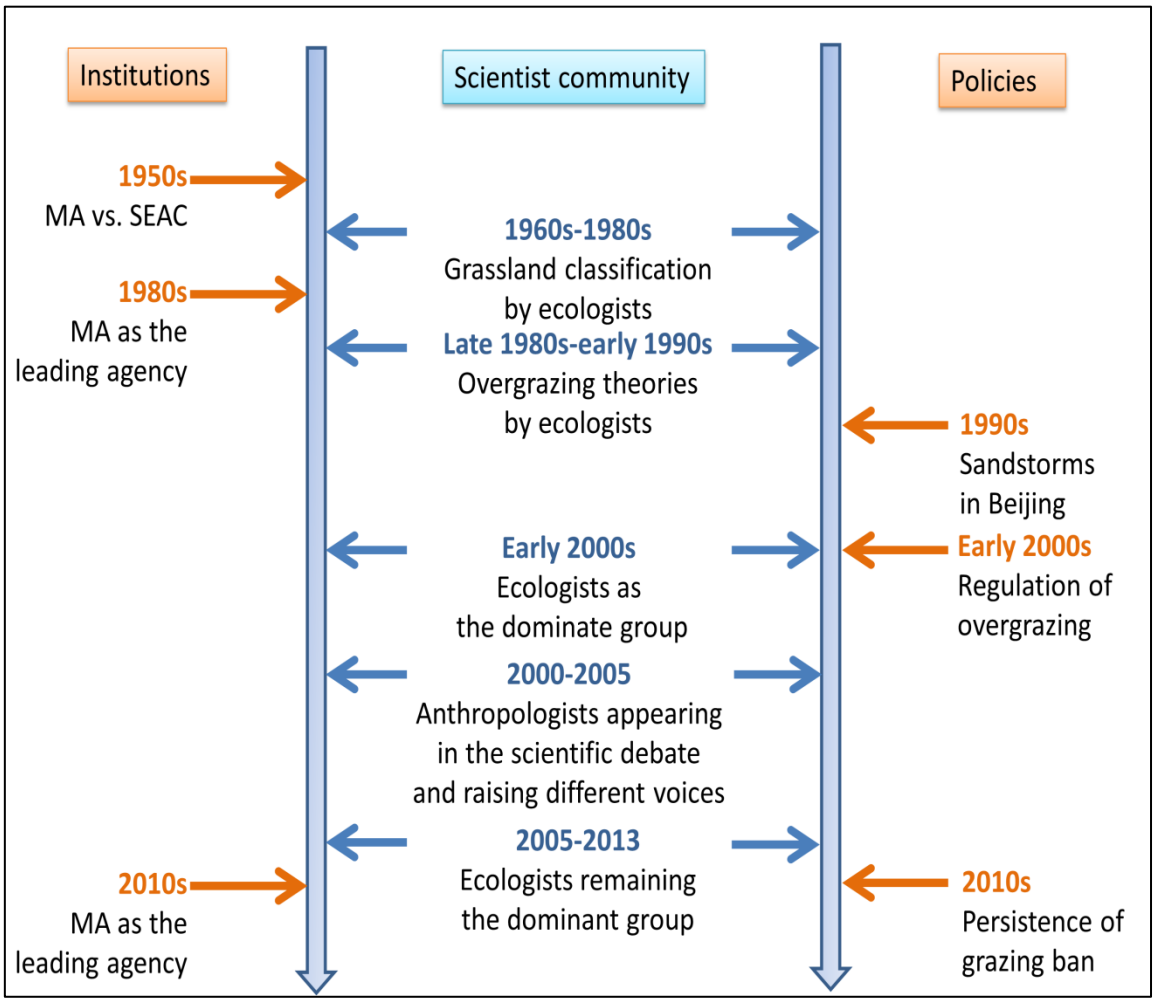

Fig. 3. Storyline of interactions among institutions, scientist community and policies

Between 2000 and 2005, the government implemented multiple grassland-management projects focusing on the regulation of overgrazing, which echoed the overgrazing narrative elaborated by ecologists A large-scale eco-migration plan, aimed at relocating nomads and pastoralists out of vulnerable ecological zones, was first initiated in Inner Mongolia in 2001 (Inner Mongolia Development and Reform Commission, 2001). Later the central government started a nationwide campaign to promote policies of seasonal or

year-round banning of grazing activities in severely-degraded areas. By the end of 2005, grazing was banned on approximately 82 million acres of grasslands (State Bureau of Environment Protection, 2006).

Around the early 2000s, anthropologists began questioning the overgrazing narrative and raised alternative explanations. However, their political impact has been limited by the structural weakness of the group. First, new ideas face the risk of being censured by old authorities (Jasanoff, 1987; Nursey-Bray et al., 2014). In this case, although anthropologists can provide alternative interpretations of the grassland problem, ecologists as the established authority are more likely to dismiss those ideas as invalid for the sake of protecting their own status. The dominant ecologist group, acting as an information filter, controls the passing of environmental knowledge from scholars to policymakers. Second, anthropologists have fewer political affiliations, as shown in Table 1. Six out of 45 anthropologists have political affiliation compared with 27 out of 55 ecologists who either work in administrative institutions or government-associated think tanks. Four anthropologists are associated with SEAC by directly participating in major research projects funded by this institution. Considering the weak authority of SEAC in the administrative system of grassland management, which was analyzed in

Chapter 2, this affiliation with SEAC is unlikely to bring them political influence. It is therefore more difficult for anthropologists to pass their ideas to policymakers, especially to the officials working in MA.

Third, the influence of anthropologists is circumscribed by its lack of interdisciplinary interactions, as measured using the E-I index (see Table 2). There is a limited exchange of knowledge between anthropologists and other disciplines. Insufficient communication undermines the possible influence ecological anthropologists can exert on ecologists and other scientists. A final important consideration is the nature of social science. Compared to research in natural science, more studies in anthropology are conducted individually rather than collaboratively. As illustrated in Table 2, the anthropologist group has fewer members and fewer internal links (45 scientists with 146 internal links) than the ecologist group (55 scientists with 230 internal links). In other words, anthropologists constitute a group with a smaller size and weaker intra-group connection. Therefore, the collective voice of anthropologists is weaker than that of ecologists.

The result of the power struggles between ecologists and anthropologists is the

continuation of overgrazing-focused grassland management between 2005 and 2013. The alternative argument—given by anthropologists—has not mustered enough political support to challenge the overgrazing narrative. The persistence of the overgrazing narrative can be discerned from the Five-year National Plan for the Promotion of Pastoralism (2011-2015), in which the central government advocated further control of overgrazing (Ministry of Agriculture, 2011). In this national plan, traditional practices of nomadism/pastoralism continue to be considered backward, unproductive, and destructive to the natural environment, and the application of 'scientific knowledge', rather than indigenous knowledge, is deemed necessary for modernizing nomadic/pastoralist communities.

3.6. Conclusion

The network-based analysis of scientist network in China helps us better understand how the power dynamics inside the scientist community influences the interpretation of environmental problems and the formation of grassland policies. By 2013, the scientist community was composed of two major clusters of scientists—grassland ecologists and ecological anthropologists. The power struggle between the two groups centers on the interpretation of grassland degradation. Ecologists first articulated concerns over

grassland degradation in the 1980s and 1990s. They not only formed a consensus that overgrazing by local communities was the root cause of grassland deterioration, but also became the main advisory group leading government efforts in grassland management. In contrast, anthropologists joined the grassland-degradation discussion relatively late, beginning in the early 2000s. Anthropologists hold different views about grassland problems, but the structural and temporal characteristics of the scientist community they are embedded in limit their strength in challenging the authority of ecologists. Smaller group size, fewer intra-group ties and fewer political affiliations have resulted in the anthropologist group failing to invoke any change in national grassland policies.

Local communities are viewed as destroyers of their own resources and have become the targets of environmental regulation because of the domination of the overgrazing narrative. This argument justifies top-down government intervention, which disregards local traditional knowledge and practices. It should be noted here that blaming local communities for environmental degradation is commonly observed in countries and regions other than China (Dove, 2006). Scholars worldwide have challenged this paradigm of environmental explanations (Dahlberg, 1994; Davis, 2005; Weisiger and Cronon, 2011).

This study illustrated that power dynamics inside the scientist community must be taken into account to understand the production of environmental knowledge and the formation of environmental policies. This conclusion invites further empirical analysis of scientist networks and their impact on other fields of environmental management. A large variety of scientist communities associated with environmental management still need to be examined to improve our understanding of the influence of academic competition on political decision-making in the science-policy interface.

After knowing that the struggles between ecologists and anthropologists have greatly affected the policymaking in China, other questions emerge. What factors have hindered the communication between the two groups and have prevented the formation of scientific consensus? Is there a way to facilitate the exchange of ideas across disciplinary divides? These questions will be discussed in the following chapter.

4. Interdisciplinary interaction and the politics of environmental knowledge: A comparison of scientist networks in China and the United States

4.1. Introduction

The analysis in Chapter 3 brought to surface the limited communication between ecologists and anthropologists and the resulting one-sided understanding of grassland problems. What factors limited the exchange of ideas and collaboration between the two groups? One easy answer is disciplinary barriers—clashes among various disciplinary perspectives disrupt interdisciplinary interactions and restrain the potential of thinking collectively in generating new solutions. However, this is not enough. The underlying—institutional and structural—factors behind those disciplinary barriers must be examined to understand an intellectual climate in which interdisciplinary collaboration is discouraged (Amey and Brown 2004).

This chapter continues the exploration of the scientist networks with the intention to identify those structural barriers to interdisciplinary interactions inside the scientist communities. If the Chinese network represents a case of limited interdisciplinary interactions, is there a network that develops in a possible situation that can serve as a counter example? This thinking led to the comparison of two scientist networks—one

from China and the other from the United States. Similar to the sandstorms in the 1990s in China, the United States suffered through the Dust Bowl in the 1930s. These environment events, like their counterparts in China, also received a great degree of publicity. The similar experiences of the two countries provide a valuable opportunity for analyzing the scientist communities that developed and evolved in different settings, and formed their unique patterns of interdisciplinary interactions. By revealing the structural differences between the two networks, we are able to comment on the conditions that encourage or obstruct interdisciplinary interactions and thus the flow of knowledge and ideas.

4.2. Literature review: Interdisciplinarity and the production of knowledge

Many scholars stress the importance of examining the way in which environmental knowledge is generated and transferred, for it not only affects the framing of environmental problems but also shapes the formation of theoretical interpretations and the identification of possible solutions (Juntti et al. 2009, Weiss et al. 2012, Bracken and Oughton 2013). Many believe that co-production and equal sharing of environmental knowledge are crucial for achieving comprehensive understanding of environmental issues, building consensus across stakeholders, and facilitating collective action on a large scale (Jasanoff 2004, Lemos and Morehouse 2005, Goldman et al. 2011). It is also

in those discussions the importance of interdisciplinary collaboration is emphasized for its role in encouraging knowledge exchange and integration (O'Brien et al. 2013, Fazey et al. 2014).

Even though the importance of interdisciplinarity has been well argued, our knowledge of its underlying mechanism remains limited. Some studies, focusing on the choices of individual scholars, try to reveal the potential benefits of interdisciplinary collaboration by exploring its impact on research productivity or impact (Gonzalez-Brambila et al. 2013, Li et al. 2013a). Some studies suggest that researchers, when informed with their structural position in the network, would manipulate their status as brokers between different groups to increase their chance of citation or influence (Li et al. 2013a p. 1528). However, what is lacking in those studies is the focus on the collective influence of research group as a whole. Group-level dynamics of interdisciplinarity—its structural pattern and its contribution to cross-discipline knowledge exchange—have not yet received enough academic attention.

Few studies have touched the issues of interdisciplinarity at group level. Huutoniemi and others (2010, p. 80) suggest that the evaluation of interdisciplinarity includes the

gauging of the scope of interdisciplinarity—which means the estimation of "conceptual and cultural distance between the participating research fields". Knowledge evaluators have to be able to identify all participatory disciplines in one field of study and decide whether collaborating disciplines have shared a large portion of theoretical/methodological foundation in common or have diverged substantially in their analytical/interpretative frameworks. This identification of research fields and appraising "conceptual and cultural" distances in-between is considered one of the crucial steps towards a comprehensive evaluation of interdisciplinary.

Some scholars point out that beyond individual-level collaboration, the promise of interdisciplinarity lies in the momentum that stimulates a larger-scale restructuring and synthesizing of knowledge(s) and perspectives across disciplines (Raina et al. 2006, Huutoniemi et al. 2010). A case study in India demonstrates the facts that the proliferation of disciplines and knowledge(s) in the field of soil science has imposed increasing pressure on traditional knowledge-generating institutions and that the failure of such institutions to accommodate a vibrant, multi-disciplinary knowledge system has therefore resulted in a limited understanding of social reality (Raina et al. 2006). This example also epitomizes the same conundrum faced by other comprehensive fields

(such as environmental sciences). In a domain that embraces a variety of disciplines, the lack of deep understanding of interdisciplinary dynamics has prevented the critical evaluation of the research field as well as the knowledge being produced. This is the reason why examining interdisciplinary interaction at group level holds significant meanings for many comprehensive, multidisciplinary knowledge domains.

There is no doubt that something important is happening at the group level. In this study, we try to explore this group-level dynamics of interdisciplinarity by adopting the approach of social network analysis.

4.3. Data Preparation and Methodology

As stated in the methodology section of the Chapter 3, we also choose to use social network analysis for the purpose of the visualization and quantification of the networks. Following the similar line of the network-based analysis on Chinese side, which defines connections between scholars as citation relations, the American scientist networks was also constructed based on bibliometric data.

The key to data preparation here is to find the right target groups inside the American

scientist communities. The knowledge of the general history of the two academic networks and the cautious selections of sampling methods help narrow down the search and find out the target groups that fit our concern. In the Chapter 3, snowball sampling method was used to identify Chinese scholars engaged in the debate of grassland degradation. The fact that there is no strong evidence of the existence of academic debate back in the 1930s in the United States renders the use of snowball sampling method here problematic. We therefore decide to do a larger scale of searching by using the combination of keyword sampling and ego-centric sampling in order to include all the possible relevant scholars.

For ego-centric sampling, a known group of key scholars is selected by referring to historical studies of major disciplines and influential scholars. We set our focus to the period between 1920 and 1950 to cover the scientist communities concerned with the 1930s Dust Bowl, which then dictates our choice of database—JSTOR (the database containing more early collections of social science journals than other databases, say, Web of Science). We limit our search to three major domains (anthropology, geography and ecology), which have already been categorized by JSTOR as anthropology, geography & geology, and biological science. The exclusion of economy in the

sampling process is due to the fact that few economists in the United States at that time were concerned with grassland degradation or the Dust Bowls. Although economic geographers touched upon certain economic issues related to the events, but in this research we categorize them as geographers rather than economists. The summary of selections of key words and important scholars are shown in the Table 3.

Table 3. Sampling method for the American networks

Disciplines (USA)	**Key-word sampling**	**No. of papers**
Anthropology	(("grassland" OR "prairie") AND ("destruction" OR "degradation"))	41
Geography & Geology	(("grassland" OR "prairie") AND ("destruction" OR "degradation"))	134
Biological science	(("grassland" OR "prairie") AND ("destruction" OR "degradation"))	627
	Ego-centric sampling	
Anthropology Geography and geology Biological science	"Barrows, H. H", "Sauer, C. O", "Alfred L. Kroeber", "Arthur W. Sampson" and etc.	99
Total	Excluding repeated or irrelevant papers (such as papers written by British scholars)	318

By following those sampling procedures, we have collected and constructed one corpuses for the network analysis of the American scientist communities. 318 papers

were identified. By extracting authors from those papers and their citation relationships between each other, we are able to construct author-to-author matrices for the American network, with authors represented as nodes in the networks and their citations and references between each other as directed links.

4.4. Results

Based on the sample data, we are able to get the first glimpse of the scientist networks that have emerged and developed during the 1920s and 1950s in the United States. The main component of the network in the United States contains 267 scholars. The size of the American network is different from that of the Chinese network. This is mostly due to two reasons. One reason is the adoption of different sampling methods, as mentioned in data preparation. The other reason may be explained by different citation culture and practices—it seems that American scholars tend to cite more than their Chinese counterparts.

Thanks to social network analysis, we could compare the two networks in the Fig. 4. The layouts are produced using the standard spring embedder algorithm in the ORA software (Carley et al. 2013). It is obvious that the two networks have formed different

patterns of interdisciplinary interactions. In the American network, there are three major disciplines with one group of scholars (geographers) locating itself right in-between. This suggests the potential existence of a brokerage community in the network. To the contrary, the scientist network in China consists of multiple disciplines with no presence of a clearly-defined brokerage community.

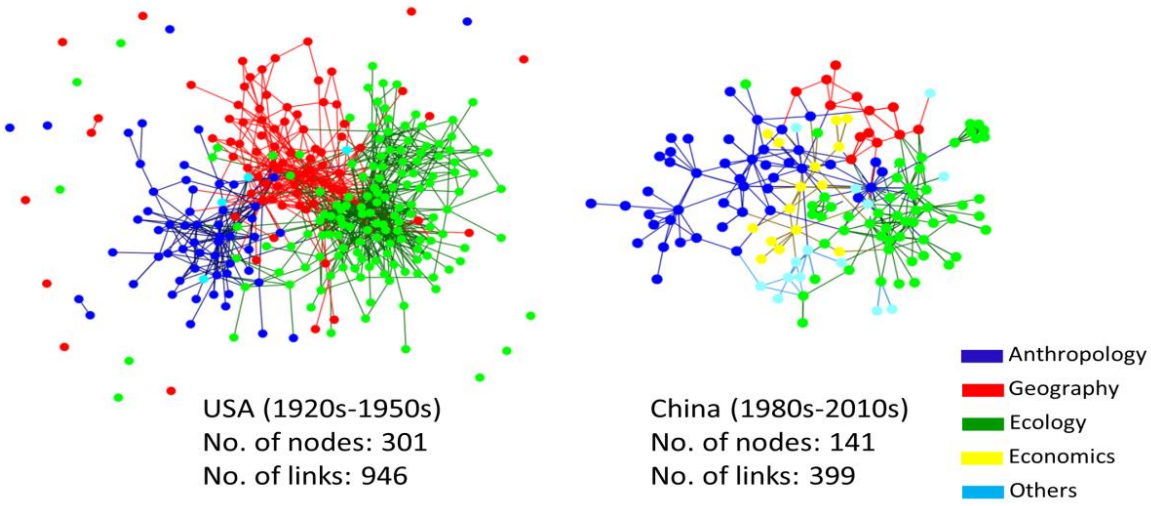

Fig. 4. Two scientist networks colored by disciplines

The presence/absence of the brokerage community can be measured in a quantitative way using block model (Table 4). Block model is a way of measuring interdisciplinary interactions by demarcating each disciplinary group as one block and then calculating the total numbers of links within and between blocks. The normalized results are shown

in Table 4, with the columns representing cited disciplines. In the American academia, geographers interacted with both anthropologists and ecologists. Moreover, anthropologists referred to geographers more often than they did to ecologists, and in a similar manner, ecologists cited more works in geography than those in anthropology. On China's side, however, the references do not converge in one discipline. Both Economists and geographers fail to be the brokers between ecology and anthropology. That is because ecologists do not cite the works of economists and geographers do not refer to the ecological studies.

The emergence of the bridge groups and its changing status in the continuously-evolving networks was illustrated in Fig. 5. The communities of geographers (which appear in red in both networks) showed up relatively early in both networks with the potential to develop further as bridge groups. As the networks expand over time, the statuses of geographers in both networks changed correspondingly. In Chinese academia, when more disciplines joined the network, historical geographers became marginalized and lost their potential as knowledge brokers; on the American side, however, the status of geographers remained central throughout all stages, bridging the clusters of anthropologists and ecologists. The comparison of the sizes of the two

geographer groups shows that the group of historical geography on the China's side is much smaller and does not change much after certain point, which also suggests its limited development and weak influence in the network.

Table 4. Block model

America				
	Anthropology	Ecology	Geography	others
Anthropology	0.0308	0.0014	0.0029	0.0000
Ecology	0.0010	0.0210	0.0058	0.0000
Geography	0.0017	0.0026	0.0259	0.0000
others	0.0208	0.0050	0.0291	0.0000

China					
	Anthropology	Ecology	Geography	Economics	Others
Anthropology	0.0465	0.0066	0.0105	0.0136	0.0032
Ecology	0.0008	0.0589	0.0084	0.0000	0.0156
Geography	0.0017	0.0000	0.1474	**0.0000**	**0.0110**
Economics	0.0136	0.0036	0.0000	**0.0952**	**0.0143**
Others	0.0016	0.0117	0.0000	**0.0000**	**0.0659**

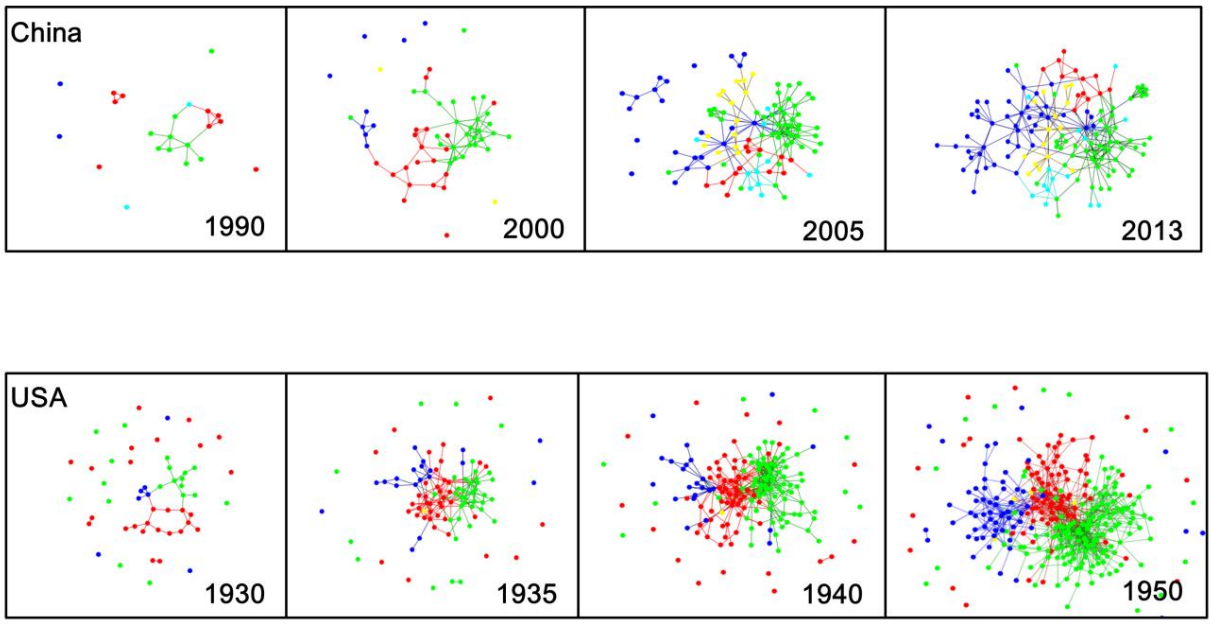

Fig. 5. Evolutions of two scientist networks over time

4.5. Discussions

4.5.1. Historical processes and the formation of brokerage community

What facilitates the development of the brokerage group in the American network? Apparently there are some historical, contextual factors that could not be revealed by the social network analysis alone. Those factors become evident once we start to dig into the historical processes that have affected the formation and evolution of the two networks. And it turns out that the actor-facilitated cross-disciplinary communication and collective efforts among engaging scholars in searching for common ground are critical in bringing out positive changes in academic networks.

For the United States, the years between 1920s and 1950s are a quite intellectually active historical period. Three disciplines—geography, ecology and anthropology—were all experiencing different degrees of interdisciplinary interactions. The relationship between ecologists and geographers started to surface in the late 1910s, when scholars from both sides explicitly discussed the possible contribution of the other discipline to their own domain: Moore included in his Presidential Address to the Ecological Society of American in 1919 that "Geography, insofar as it is the study of man in relation to his environment, is human ecology" (Moore 1920 cited in Koelsch 1969 p. 638); correspondingly, Dryer, as the president of the Association of American Geographers, delivered a Presidential Address in the same year pointing out that "ecology may do for human geography as much as geology has done for physical geography" (Dryer 1920 cited in Koelsch 1969 p. 638). Shortly afterward, Barrow as the new president of AAG further affirmed the idea of interdisciplinary integration by developing his own definition of geography in 1923, which is indicated by the title of his address "Geography as Human Ecology". He argued that "I came to realize that American history, on its material side, fundamentally is largely a record of the adjustments of a rapidly expanding people to varied environments" (Barrows 1923 cited in Koelsch 1969 p. 639). All those efforts suggest an increasing interest among

ecologists and geographers in the work of each other.

On the other hand, the connection between anthropology and geography inside the American academia is rather implicit. The possible theoretical interactions could be traced back to Boas, who was first trained as a geographer and later changed his focus domain to anthropology. The theoretical exchanges between the two got intensified around the 1920s and 1930s, which some scholars believe was partly due to the personal connections, developed in the University of California, Berkeley, between Sauer and two Baos's former students—A. L. Kroeber and Robert Lowie (Jackson 1989). They experimented combined anthropology/geography seminars and field studies, and even discussed the possibility of a joint department (Kerns 2008). The collaboration between anthropology and geography at the UC Berkeley in the 1920s and 1930s is considered to have left a rich intellectual legacy for students graduating from the program, with the genealogy continued to Julian Steward and other scholars (Kerns 2008).

After linking the historical facts to the development of American scientist networks, we come to better understand why it is geography, rather than other disciplines, that is able to locate itself at the center of interdisciplinary exchange during the years between the

1920s and the 1950s. The role of geographers as a brokerage community is partly derived from their desire to redefine the discipline as an integrated, distinguished domain—as is attempted by Barrows. And its privileged connection with anthropology is partly a result of personal interactions among scholars in the University of California, Berkeley, where intensified theoretical exchanges between geographer and anthropology become possible. Connecting historical details with social networks, just like adding flesh to bones, gives us a vivid picture of what was going on back then inside the networks. The historical interpretation of interdisciplinary interactions and the quantitative analysis of scholar communities work hand in hand to reveal to us the behind-the-scene mechanisms that have influenced the development of the brokerage community.

Now we turn our gaze to Chinese network that developed during the 1980s and 2010s. What we observe is that major disciplines participating in the discussion of environmental problems have relatively independent histories of development without crossing paths with each other. One of the disciplines—historical geography—developed and elaborated the interpretation of land destruction and degradation much ahead of other disciplines. One famous historical geographer—Hou

Renzhi—carried out several famous historical studies concerned with desertification around the end of the 1950s and the beginning of 1960s (Hou and W. 1973). Following historical geographers, ecologists also started to build their own models and grassland classification system (Wu and Loucks 1992). Later, scholars from other fields joined in the discussion—with the group of anthropologists showing up around the year 2005.

Not only do those disciplines start to engage in the study of grassland at different historical points, their research focuses and theoretical frameworks are also quite diverse. Historical geography tries to figure out the causes of desertification by digging into historical archives and their targets are, more often than not, historical agricultural practices. Ecologists, however, set their focus on the destructive impact of grazing activities on environmental ecosystem. Quite different from these two disciplines, anthropologists have a wider range of interest, covering topics from sociopolitical relationship between farming and grazing to marketization and modernization of local communities (Yeh 2005, Zhang 2008a, Li and Huntsinger 2011, Yeh et al. 2014). Due to those different histories of development and divergent research focuses, interdisciplinary communications across disciplines are quite limited in China.

4.5.2. Brokerage community and interdisciplinary communications

Have the presence of brokerage community make a difference? What is the contribution of brokerage community in terms of bridging differences and synthesizing ideas? To answer these questions, we have to look into the ideas being circulated and the knowledge being produced inside the networks.

In the American academia, we find the interpretation of grassland degradation inside the brokerage community seems to incorporate perspectives and ideas across disciplines. Following the environmental events, each discipline gives its own version of this story. American ecologists emphasize the destructive impact of the farming practices of Anglo-Saxon migrants who were attracted to the West by railway, the Homestead Act as well as the expanding market for wheat (Albertson 1941 p. 48). Anthropologists, On the other hand, though not directly criticize those Anglo-Saxons, tend to use American Indians as the counter example of modern farming, which could be illustrated in the following argument given by Delaware and Wilder—"the Indians must have presented, and differing wholly from that of fields in which any kind of white men's crops have been grown" (1920 p. 224).

Among those discussions, geographers' stand is steadfast and unequivocal if we look into Lord's report on the progress of social conservation in the United States in 1945:

> "Only yesterday in terms of historic time the North American continent was an Indian paradise. Here was a vast and fruitful land, clad with a robe of plants that had protected it for millions of years. Suddenly this body of land was thrown open to land-hungry immigrants from Europe. With a rush we took it and beat upon it hungrily, wave by wave…we seized upon and bared American soil for what we called "cultivation." In countless places we thinned our topsoil to half or less than half its former depth and productivity" (Lord 1945 p. 159).

It seems that Geographers transform the previous two arguments given by anthropologists and ecologists into a coherent, historical narrative of the American West. By contrasting the past with the present and the Indians with Anglo-Saxon migrants, the story expressed a collective understanding about the successes and failures of human transformation of nature. If we say that geographers' brokerage position in the network gives them the advantage of synthesizing various perspectives, we can also say that it is out of this brokerage community that a historical narrative of the adaptation and

mal-adaptation comes into being. This process reflects the way in which diverse views and knowledge(s) are brought together and shape a multifaceted understanding of the social-ecological system.

The situation is rather different in the case of China, where we have found an academic landscape with divergent, or even conflicting, ideas. Historical geography is targeting farming practices in the past, ecologists focusing on overgrazing while anthropologists criticizing culturally-ignorant regulators. Among those diverging perspectives, biggest interpretative differences appear between the two major disciplines in the network (ecology and anthropology). Ecologists blame local communities as the main culprits of grassland destruction. On the contrary, anthropologists take side with local communities, emphasizing the importance of indigenous knowledge and its potential contribution to environmental conservation. Anthropologists also argue that it is problematic grassland policies in the past that have dramatically transformed local culture and compromised its effectiveness in mediating human activities and changing natural environment (Zhang 2008a, Luo 2013). There seems to be no room for the emergence of an inclusive, comprehensive understanding of environmental problems on the ground. And this situation of fragmentation and irreconcilability continues until today.

4.6. Conclusions

In this chapter, we compare two scientist networks to reveal the factors that have influenced interdisciplinary interactions and the exchange of ideas across disciplinary divides. Both networks consist of scholars concerned with the issues of grassland degradation and sand storms, but structural differences between them have led to different patterns of interdisciplinary interactions and knowledge exchange/sharing. With the help of social network analysis, we are able to visualize and quantify those structural differences, with special attention paid to the emergence and development of brokerage communities. The American scientist network is characterized by the presence of the brokerage community—mainly a group of geographers—who have played an important role as the knowledge channel between another two major disciplines—anthropology and ecology. In contrast, the Chinese scientist network has no clear sign of the existence of brokerage community and consists of scholar clusters with limited interactions among each other.

By connecting the evolution of scientist networks with historical details of interdisciplinary interactions, we are able to understand the underlying mechanisms that

bring the brokerage community into being. The theoretical reorientation within American geography in the 1920s helps it to become a middle ground for idea sharing between different research communities. Its status derives both from geographers' desire to develop geography as an inclusive, comprehensive field and from the common theoretical/methodological foundations it has shared with other disciplines (ecology and anthropology). The same network, however, does not take shape in China in the 1990s, when the similar environmental problem has plagued China. Relatively independent research focus and interpretative framework of participatory fields have limited group-level interdisciplinary interactions.

The presence of brokerage community does have consequences for the exchange of environmental knowledge across disciplines. The American scientist network is able to produce an inclusive, multidisciplinary framework of interpretation. The explanations of environmental problems given by geographers are a mixed story that integrates assumptions and ideas from both anthropology and ecology. In China, however, due to the absence of brokerage groups mediating between major disciplines, environmental interpretations remain fragmented and unnegotiable—each cluster upholding its own research focus while unwilling to reconcile with other disciplines.

In this study of interdisciplinarity, we find that, at the group level, the development of brokerage community is crucial for facilitating knowledge exchange and building up a comprehensive understanding that accommodates different views and perspectives. Though considered as very important, the group-level dynamics of interdisciplinarity have not received enough academic attention. At policy level, there are still some difficulties in terms of evaluating group-level interdisciplinarity and incorporating it into a large-scale, long-term knowledge management agenda. More studied are needed to explore various possible patterns of group-level interdisciplinary interaction. The more we are informed about dynamics behind interdisciplinary interactions, the more likely we are able to actively influence the evaluation and management of knowledge in the future.

5. Case study: Impacts of climate change and government intervention in Inner Mongolia

5.1. Introduction

As mentioned in previous chapters, official environmental discourse in China, largely influenced by the ecologist group, targets overgrazing as the root cause of grassland degradation. A complete grazing ban in farming villages and a seasonal ban in semi-grazing/grazing villages have been implemented in the early 2000s. These regulations have greatly affected local grazing activities (Zhang 2012). The impacts of the grazing ban have been complicated by an array of other factors including climate change. Several studies indicate the potential impacts of climate change in terms of the declining productivity of farmlands and grasslands in Inner Mongolia (Dong et al. 2013, Qian et al. 2013). Remote-sensing-based studies also confirm these finding (Li et al. 2013b). Both climate change and government intervention can transform the way local communities access and utilize their resources, which sometimes has unexpected environmental consequences. This chapter uses a case study of two villages in Inner Mongolia to reveal how local communities adapted to the grazing ban in the situation where climate change occurs. This kind of micro-scale studies helps us to gain a understanding of current environmental problems and to judge on our own whether the

grassland problem is a matter of overgrazing raised by ecologists or a matter of policy failure argued by anthropologists. By taking into account the impact of local adaptive strategies on underground water, this study also allows us to evaluate the impacts of the grazing ban from the perspectives of sustainable use of natural resources.

5.2. Data and Methods

5.2.1. Study site

Two villages in Ongniud Banner, Inner Mongolia, were selected for case study (refer to Fig. 6). The farming village covers an area of 4,703 hectares, whereas the semi-grazing village covers an area of 7,201 hectares. The centers of the two are six kilometers away from each other. The farming village has 263 households, a total of 1,176 people, compared with 167 households, a total of 674 people, in the semi-grazing village. The population of the former village is mainly composed of Han Chinese, while residents of the latter are mostly Mongolians. It is also worth noting here that the villages are located in a region that is characterized by a long history of land conflicts. The origin of those conflicts can be traced back to the end of nineteenth century, when the immigration of Han Chinese into this region triggered a series of land conflicts (Borjigin 2004).

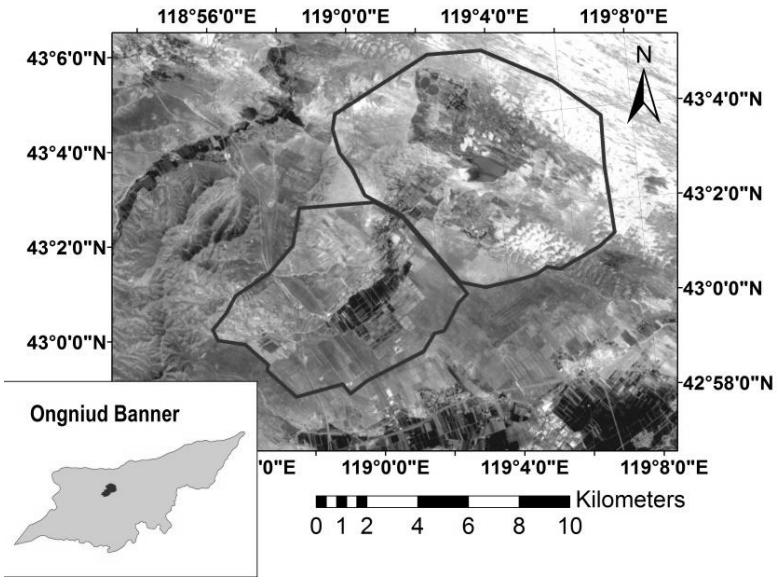

Fig. 6. Location of study sites

The climatic data shows that the region suffered from limited rainfall and declining underground water levels in recent decades. One study estimated that the total annual precipitation in Ongniud Banner, representative for this region, previously ranged from 300 to 400 mm, with the year 1991 having the most rainfall (589.7 mm) and the year 2001 the least (215.1 mm); however, for the period between 1997 and 2007, the average rainfall was 285.3 mm, which signals a significant decrease (Kang et al. 2008). The statistical data (from 1993 to 2011) summarized in Fig. 7 also confirm this situation. From 2000 to 2011, seven of twelve years had total annual precipitation below 300 mm.

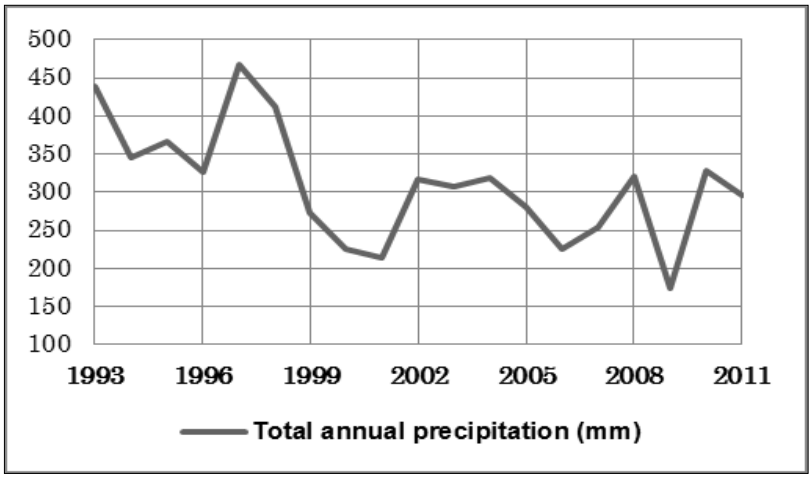

Fig. 7. Total annual precipitation (Ongniud Banner)

Both quantitative and qualitative analyses are adopted. Remote sensing analysis is applied to illustrate local vegetation changes, whereas qualitative analysis is conducted for a better understanding of local adaptive strategies and corresponding social changes.

5.2.2. Questionnaire survey

Qualitative analysis was based on interview data collected in the two villages from August 20 to September 24 in 2013. A total of 128 persons in the farming village and 49 persons in the semi-grazing village were interviewed. The ratio between male and female interviewees in the farming village is 51: 77, compared with 23: 26 in the semi-grazing village. Basic household information was collected, together with 1) perceptions of climate change, 2) local land-uses, 3) adaptive strategies, and 4) perceptions of inter-village relations. For the perceptions of inter-village relations, the

interviewees were asked to comment on the relations according to a five-degree rating system—good, relatively good, neither good nor bad, relatively bad, and bad. For other questions, the interviewees were asked to give their own answers.

5.2.3. Remote sensing analysis

The quantitative analysis was based on remote sensing data, which revealed local vegetation changes from 2000 to 2014. The MOD13Q1 vegetation index product of NASA was used for analyzing local vegetation. This product is based on multispectral information from the MODIS sensor onboard satellites Terra. Images from February 18th, 2000 to December 3rd, 2014 were downloaded from the official server (LAADS Web, 2000-2014). Landsat images of July 31, 2004 and August 9, 2013 were also used for the purpose of reference. These images were downloaded from the official server[12] (EarthExplorer, 2004 and 2013).

There are two reasons for using MODIS in vegetation analysis instead of Landsat data. First, a certain amount of images of the growing season (summer season) are necessary to allow better vegetation type determination. Landsat data has few cloud-free images during summer season for the past decade in the region of the two villages, whereas

[12] Data available from the U.S. Geological Survey.

MODIS data provides vegetation information twice a day, and MOD13Q1 composited of MODIS data allows the continual, cloud-free observation of local vegetation every 16 days. Second, the total area of two villages is large enough to allow the analysis based on 250-meter spatial resolution images.

The NDVI (Normalized Differential Vegetation Index), computed from the satellite derived surface reflectance of the red and the near infrared spectral region, was used to identify and estimate the active leaf from space (Jones and Vaughan 2010). For distinguishing vegetation covers, phenology analysis was conducted. The basic assumption of phenology analysis is that "different crops have different rates of phonological development during the season" and that it is possible to separate different vegetation types by combining spectral information with multi-temporal data (Jones and Vaughan 2010). It was carried out in two stages in this study. The first stage was the unsupervised classification of the annual NDVI changing pattern based on ISODATA Method for randomly selected samples, and the second stage was defining the classified category (class) for all other samples based on Maximum Likelihood Estimation. The software GRASS (Geographic Resources Analysis Support System) was used to conduct the phenology analysis. The unsupervised classification was made on the basis

of the twelve NDVI dataset from April to October for each year under the conditions that the minimum inter-class distance is 1.0, and that the initial class number is 50 and the terminated condition is the complete convergence.

To allow identification of different land covers for each class, the location and vegetation type of each class was cross-referenced with those in Landsat images. The comparison is shown in Fig. 8. False color images are based on cloud-free Landsat images of July 31, 2004 and August 9, 2013, and phenology analysis images are based on the twelve NDVI dataset from April to October for each year (2004 and 2013).

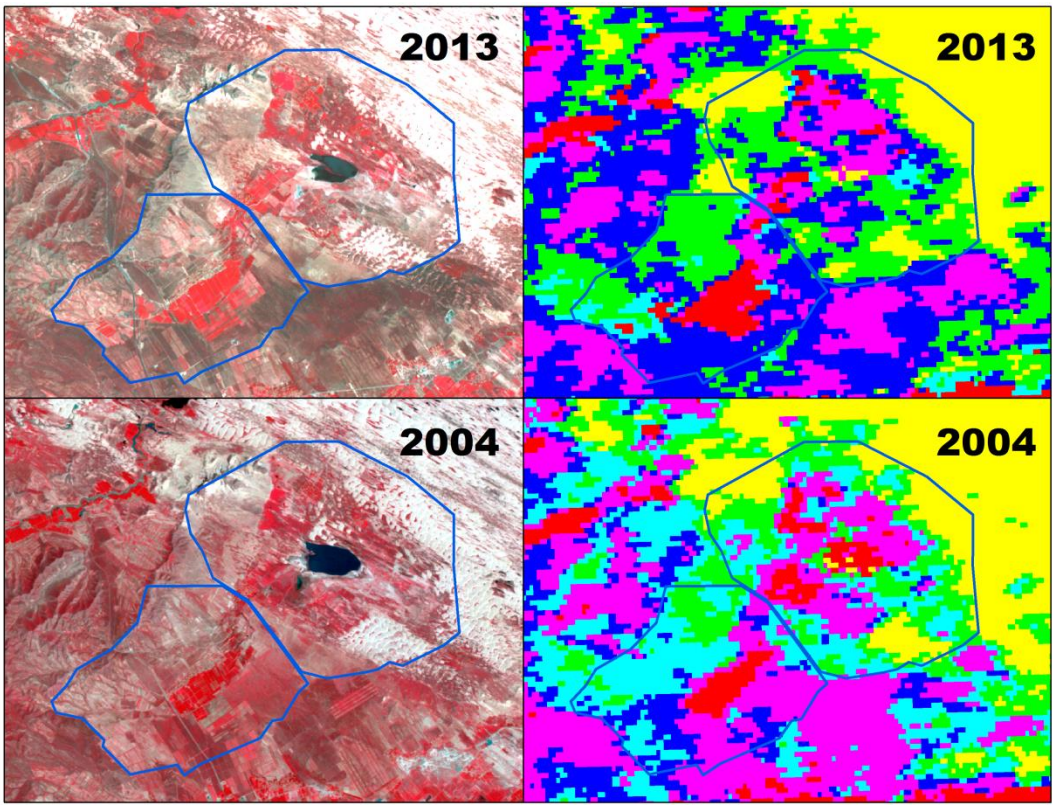

Fig. 8. False-color images (Landsat) and phenology-analysis images (MODIS)

5.5. Results

5.5.1. Local perceptions of climate change

This regional drought condition was confirmed in the interviews. Among the 177 interviewees, 174 people described the climate is getting drier; regarding the reasons for local land-cover changes, 57% of people in the farming village believed that climate change is the main cause, while 86% in the semi-grazing village believed climate change plays a major role in transforming local landscape. For adaptive strategies to the drought years and the official grazing bans, local people gave different answers. The

answer given by all the people in the farming village is to invest more in irrigated farmlands, whereas the strategy of the semi-grazing village is to purchase fodder from the farming village. About 71.4% interviewees in the semi-grazing village purchase fodders every year, with the cost varying between 5,000 RMB to 15,000 RMB. When asked about the relationship between the two villages, 93 % of people in the farming village commented that the relationship is good or relatively good, whereas the percentage in the semi-grazing village is 97%.

5.5.2. Changes in local covers

The remote sensing analysis provides a way to measure quantitatively changes in irrigated farmlands and desert grasslands from the years 2000 to 2014. As the result of the analysis, six classes were identified for each year, and some of these classes in phenology analysis could be clearly identified as certain land-covers. Class I were identified as deserts, Class II as desert grasslands, Class III, IV and V as a mixture of dry farmlands and high-NDVI-value grasslands, and Class VI as irrigated farmlands. Irrigated farmlands are shown in red in phenology-analysis images, whereas desert grasslands are in green and deserts in yellow (see Fig. 8). These land-covers can be confirmed with 30-meter resolution, false-color Landsat images, in which the colors of

irrigated farmlands, desert grasslands, deserts are bright red, light red and white respectively. Other classes (Class III, IV and V) were not used in this study because they could not identify well different vegetation covers, which include dry farmlands and grassland with higher NDVI values. Based on the land-cover classification, the total areas of irrigated farmlands (Class VI) and desert grasslands (Class II) were calculated over a 15-year span. These data help reveal changes in local farmlands and grasslands.

Changes in the area of irrigated farmlands in the farming village and the semi-grazing village are shown in Fig. 9. The irrigated farmlands have significantly increased in the farming village while decreased in the semi-grazing village. Changes in irrigated farmlands may reflect both climatic and human impacts. In this case study, the increase in the area of irrigated farmlands in the farming village illustrates that local villagers devoted more efforts in increasing their supply of water to secure their farmland harvest because of several droughts they had experienced in the past decade. On the other hand, during the drought years, the semi-grazing village failed to keep a stable amount of irrigated farmlands, which indicates their difficulties in maintaining local irrigation systems and in securing a stable supply of underground water.

Fig. 10 shows the changes in the area of desert grasslands in both villages. Though desert grasslands do not show a significant change in the farming village, there is an increase in the area of desert grasslands in the semi-grazing village. Regarding the increasing desert grasslands in semi-grazing village, its socioecological impacts can be deduced. Based on the fieldwork data, the boundary of the semi-grazing village remained stable and there was no conversion of farmlands into grasslands in this village. Therefore, the total area of all grasslands (including high-NDVI-value grasslands and desert grasslands) remains constant. As remote sensing analysis showed an increase in the area of desert grassland, the areas of high-NDVI-value grasslands must have decreased correspondingly. Considering the low contribution of desert grasslands to pastoral production, the declining areas of other grasslands suggests increasing environmental constraints on local grazing activities.

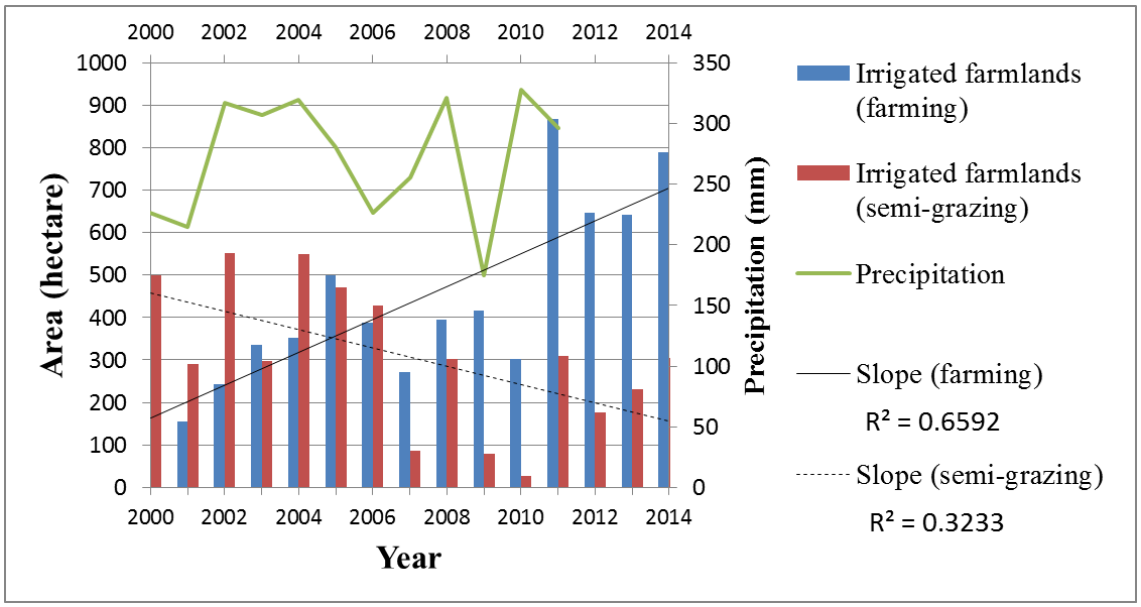

Fig. 9. Changes in farmland areas

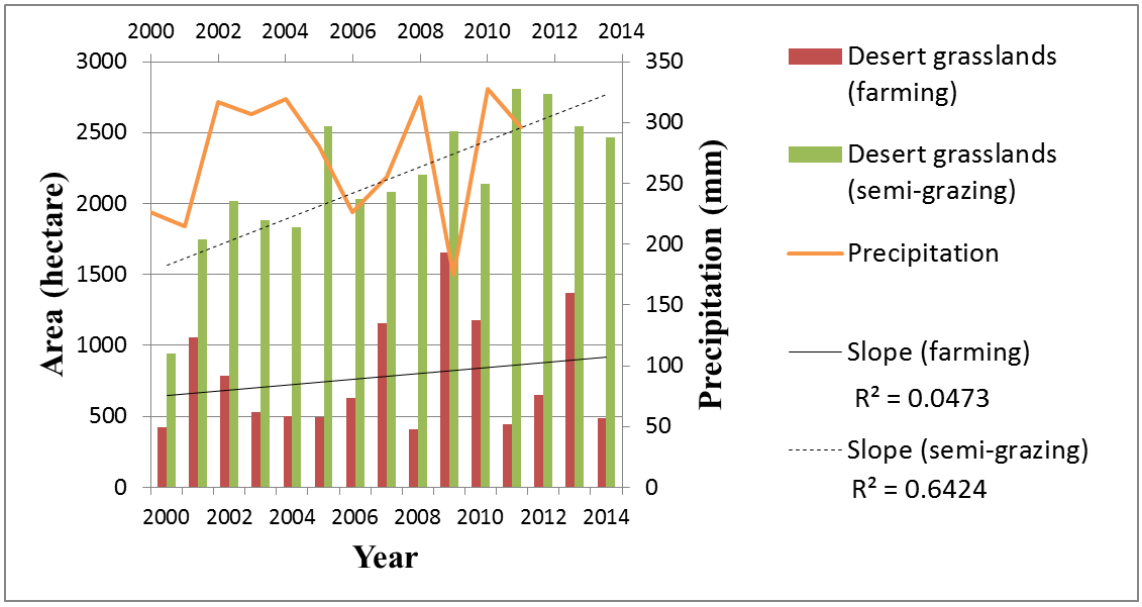

Fig. 10. Changes in desert grassland areas

5.6. Discussion

5.6.1. Adaptive strategies of the farming village

An increase in the area of irrigated farmlands in the farming village, shown in Fig. 9,

reveals the adaptive strategy of this farming village. According to the fieldwork data, people have chosen to invest more in irrigated farmlands to cope with climate change. Villagers argued that they tend to invest more in irrigated farmlands when the national government banned farmers from grazing their animals in the early 2000s. That is because without supplementary income from raising livestock, irrigated farmlands became the sole source of income. They raised external and internal funding to secure the water supply. Communal wells were dug, and the water was shared communally. In one village studied, the irrigation responsibility is shared among households during the crops important growing seasons. Households take turns watering the fields of the entire village; the labor requirement is very heavy, and sometimes the task involves remaining up all night, checking the soil condition. This process of local adaption to both climate change and government intervention explains the increase in the area of the irrigated farmlands in the farming villages in recent years.

During the interviews, villagers talked about climate change and their adaptive strategies in terms of digging deep irrigation wells and organizing communal irrigation activities. Some business men in the farming village offered to support communal well-digging financially and the water is shared communally. Because of the importance

of irrigation activities, households began to share irrigation responsibility, taking turns to water irrigated farmlands of the whole village at important growing seasons.

5.6.2. Adaptive strategies of the semi-grazing village

Fig. 9 and Fig. 10 reveal changes in both irrigated farmlands and desert grasslands of the semi-grazing village: 1) the total area of irrigated farmlands has declined over time, and 2) the area of desert grasslands has significantly increased, which suggests the declining of other grass resources. Both changes must have affected the grazing activities of the village.

Farming is traditionally a complementary part to grazing in the semi-grazing village. Crop residues are stored and used as fodder in winter. The decrease in the area of irrigated farmlands in the semi-grazing village, shown in Fig. 9, means that less and less crop residues can be used for winter livestock-raising. Besides the fodder supply from farmlands, there is another important source of fodder for winter—that is, collected grass. According to Fig. 10, in the semi-grazing village, the area of the desert grasslands has significantly increased whereas the area of other grasslands with higher pastoral values has been decreasing. These changes suggest that the amount of grass that can be

collected by villagers has become more limited.

Because winter fodder supply from both farmlands and grasslands are reduced, local people have to face the problem of fodder shortage. Fodder shortage in drought years is common in pastoral societies (Wang and Zhang 2012). The semi-grazing village is not exceptional to this problem. In addition to difficulties introduced by climate change, the seasonal ban of grazing implemented in the village makes the problem of fodder shortage even more severe. The central government prohibits livestock from entering rangelands during the early spring to allow the reproduction of grasslands. This inevitably prolongs the period of keeping livestock indoors and thus increases the local need for fodder.

To cope with fodder shortage, the semi-grazing village has managed to develop a trading relationship with the farming village nearby. Based on the interview results, about 71.4% interviewees in the semi-grazing village purchase fodders every year, with the cost varying between 5,000 RMB to 15,000 RMB. According to the descriptions of local people, the trade started almost a decade ago. The fodder being exchanged is mainly crop residues after autumn harvest.

5.6.3. Inter-village relationships

Considering that the two villages are located in a region that is characterized by a long history of ethnic conflicts over lands and natural resources (Borjigin 2004), the trade may have some positive impacts on the inter-villager relationship. In the interviews, 93 % of people in the farming village thought that the relationship is good or relatively good, whereas the ratio in the semi-grazing village is 97%. Interviewees confirmed that the fodder trade can partly explain the intensified interaction between the two villages and the improved ethnic relationship.

Despite the fact of the improved relationship, this inter-village trade is unlikely to last long. The trade between the two villages involves crop residues that come from the irrigated farmlands of the farming village. These irrigated farmlands depend heavily on underground water. Over years, the trend of overusing underground water has become increasingly pronounced. According to the villagers in the farming village, the average depth of communal irrigation wells changed from 40 meters in the early 1990s to more than 90 meters in 2013. Considering the declining tendency of the underground water level caused by reduced precipitation and human overuse, the water may become

unreachable or completely depleted in the near future. If this scenario occurs, the decline in agricultural productivity in the farming villages could lead to the abrupt ending of the regional fodder trade, and cause potential crisis in both communities.

5.7. Conclusion

In this chapter, both quantitative (remote sensing) and qualitative data are utilized to analyze the strategies of local communities to adapt to changes brought about by the grazing ban and droughts. The integration of quantitative and qualitative analysis helped to deepen our understanding of these local dynamics against the context of the grazing ban and climate change. Different investment efforts, coping tactics and inter-communal connections deployed by the two different communities were revealed: 1) the farming community has chosen to secure their living by devoting more efforts into irrigated farmlands; 2) the semi-grazing community, on the other hand, has solved the problem of fodder shortage by trading crop residues with their farming neighbors. Although the trade between the two villages has helped to improve inter-village relationship, it is important to point out that this inter-village linkage is unlikely to be stable considering the risk of underground water depletion in the near future. These findings raise questions about the current grazing-ban policies and its underlying environmental

assumptions. The grazing ban has limited the economic choices of the farming village and deepened the problem of fodder shortage in the semi-grazing village.

Conclusion

Institutionalized policy-making process

From the privatization in the 1980s to the recent Grazing Ban policies in the 2000s, local communities are continuously seen as the culprits of grassland degradation. Instead of learning from local experience in grassland management, the government lays blame on the backwardness of nomadism/pastoralism; modernization and industrialization are advocated as the solution to environmental problems. Instead of only criticizing those biased environmental discourse and policies, the focus of this study is extended to include the policymaking processes behind environmental management. By applying a processual, dynamic approach, this study revealed how the power struggles between institutional agencies and inside scientist networks had influenced and shaped the orientation of national grassland policies.

The official environmental discourses and grassland policies have first been influenced by the institutional arrangement. A historical process of institutional restructuring in the administrative system was reviewed in Chapter 2. As MA plays an increasingly important role in grassland management, the political debate over cultural tradition of nomadism/pastoralism ended. Pastoralism is no longer seen as imbedded in particular social and cultural contexts, but is deemed necessary to follow the path of

industrialization and modernization.

The national grassland policies have also been supported by the scientist community, particularly by the ecologist group, which was revealed in the Chapter 3. The dominance of ecologists led to the prevalence of the overgrazing-causes-degradation discourse. Though anthropologists later questioned the narrative, their capacity to challenge the authority of ecologists was circumscribed by their small group size, weak intra-group connection, and limited political affiliation. This resulted in the persistence of biased policies that continue to blame local communities for environmental problems.

The examination of government institutions and scientist networks involved in grassland policymaking reveals the political alliance between officials and scientist groups over the years. The higher percentage of ecologists working in government institutions and think tanks implies the official recognition of the validity of their environmental knowledge, which in turn provides ecologists the power to disseminate their theories and models. As the largest scholar group inside the network that has benefited from the government support, grassland ecologists may have more interest in

maintaining the status quo than questioning their past theories and underlying assumptions. The converging interests between the ecologists and the administrative agencies make this science-policy alliance extremely difficult to break. Even when the old environmental explanations are challenged by new scholar groups, the findings of ecologists are continually considered by officials as scientifically sound and valid.

Interdisciplinary interaction and knowledge exchange

The social network analysis of the Chinese scientist community shed light on the disciplinary divide between ecologists and anthropologists. The natural scientists (mainly ecologists) and social scientists (mainly anthropologists) formed enclosed clusters and had limited communication between each other. A further comparison of the Chinese scientist community with its American counterpart revealed the absence of a brokerage group on the Chinese side, which is considered as one of structural barriers that might have led to diverging environmental understandings and a lack of scientific consensus. These findings, echoing the calls of scholars for more interdisciplinary collaboration, raise the importance of managing interdisciplinary interaction in the long term for a balanced representation of both natural and social scientists in the production of environmental knowledge.

Criticizing the dominance of ecologists and advocating the interdisciplinary collaboration in grassland management does not mean that ecologists and other naturel scientists have no valid and valuable insights into environmental problems. The purpose of this study is to raise the awareness of the limitation of one-sided scientific findings and to promote a political stance that takes into consideration the equal participation of all scientist groups. By maintaining critical of one-sided scientific findings, we exposes the political nature of science and opens up new spaces for scientific dialogue between competing theories and models, which in turn improves our understanding of the human-nature relations.

Political implication of this study

MA, as a government agency specialized in agricultural production, has no doubt about the righteousness of extending its agricultural policies into the pastoral sectors, unaware of the fact that the grassland environment and the pastoral societies are governed by a different set of ecological principles. The complex socio-ecological systems on grasslands are reduced to statistical data on meat and wool production, charted and published as the evidences of the achievement MA has made. This problematic approach adopted by MA receives no objection because of the absence of other

institutions that can counterbalance the authority of MA in the administrative system.

A possible solution for future policy reform is to change the dominate status of MA and to restore institutional balance. This can be achieved by either adding a new institution into the administrative system or by increasing the authority of the SEAC in grassland management. In this way, the political interests of MA can be put under the scrutiny of other institutions, and the biased policies issued by MA can be exposed to open discussion and conflicting views. This kind of institutional balance is fundamental to the formulation of environmental policies designed for the common good.

More interdisciplinary collaboration in the field of grassland management is also indispensable for generating a comprehensive understanding of grassland problems and guiding the making of a well-balanced environmental policies. So far the disciplinary divides still remain. Ecologists point to the problem of overgrazing and underdeveloped pastoralism, whereas social scientists, anthropologists in particular, emphasize the environmental impact of government interference that disregards local knowledge and practices. There is no doubt that a new platform for dialogue across disciplines is needed. A group of scientists with interdisciplinary training or interested in

interdisciplinary collaboration can serve as a brokerage group between natural scientists and social scientists. Through the exchange of knowledge and ideas, members of one scientist group can learn other ways of observing and interpreting environmental phenomena which complement their disciplinary perspectives. It is this kind of communication—a communication based on respect and sharing—that affords the opportunity for creating new approaches to grassland management in the near future.

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