

Seven design principles for promoting scholars' participation in combating desertification

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Desertification has been widely recognized as a major environmental and ecological problem facing humanity today. Combating desertification is a global challenge for sustainable development and requires collective action involving government, local communities, businesses, NGOs, and international organizations. Scholars' role in this important endeavor and their mechanisms of participation, however, has received little attention in the mainstream discourse concerning global desertification control. Comparing and contrasting 30 case studies around the world, our study suggests that successful scholar-participated governance needs to satisfy seven design principles: (i) sustained participation of field-based scholars; (ii) federal organizational structure and concrete and stratified roles; (iii) democratic and collaborative management with strictly implemented mechanisms of awards and sanctions; (iv) consistent local scholar entrepreneurship; (v) realization of expected benefits; (vi) experiment–extension methods; and (vii) reliable external support. The better satisfied these principles are, the more successful is the effort to combat desertification. These findings provide evidence that stronger proactive participation of scientists and practitioners is urgently needed to tackle pressing environmental problems such as desertification.

Keywords: participation mechanisms; desertification control; collective action; scholar-participated governance

Introduction

Desertification usually refers to land degradation in arid, semi-arid, and dry sub-humid regions due to human activities and climate variations, which may lead to the permanent loss of land productivity (UN 1992; Zha and Gao 1997; Glenn et al. 1998; Rasmussen et al. 2001; Wu 2001; Yang et al. 2005; Wang et al. 2006). These dryland regions together cover about 41% of the global land surface and are home to more than 38% of the world's human population (Verón et al. 2006; Reynolds et al. 2007). Desertification often has serious consequences and directly affects about 250 million people in developing countries (Reynolds et al. 2007). The United Nations Environment Programme (UNEP 2003) pointed out that appropriately 5 million km² of global land (including two-thirds of productive agricultural land) have been affected by land degradation. According to the Millennium Ecosystem Assessment (MEA), an area of 10–20 million km², or about 10–20% of global drylands, has been degraded (MEA 2005). GTZ (2005) also estimated that about 50,000–60,000 km² of global land are being permanently lost to agriculture each year because of human-induced soil degradation. In China over the past several decades, this process has become even more serious and evident (Yang et al. 2005; Huang and Siegert 2006; Zhang et al. 2006). The annual invasion speed of desertification process was 1560 km² in the 1950s, but in 2002 this expanded to 10,400 km² (CCICCD 2002). Understanding the mechanisms of desertification and developing effective management and mitigation plans is increasingly important for maintaining ecological and socioeconomic sustainability, as well as

political stability, of both the dryland areas and the entire world (Wu 2001, 2005; Reynolds et al. 2007).

Many researchers have highlighted the important roles of government (Sheehy 1992), business (Skuras et al. 2000), local people or communities (Reynolds et al. 2007), various NGOs or international organizations (UNCCD 1994; Betsill and Corell 2008; Stringer 2008), and local and scientific knowledge in combating desertification (Fullen and Mitchell 1994; Thomas 1997; Zha and Gao 1997; Fan and Zhou 2001; Tschakert 2007). Although scholars also play an important role in resolving collective action dilemmas in various fields, including combating desertification (Yang 2007a, 2007b; Yang and Wu 2009), the functions of scholars as a group of independent social actors and the mechanisms of scholars' participation have received little attention in the mainstream discourse concerning contemporary desertification control. Addressing these problems is particularly crucial for sustainable development in arid and semiarid regions around the world, which is the primary goal of our study.

In this study, we define 'scholars' broadly as those individuals who have comparative advantages in knowledge over other social actors. Knowledge represents capital that plays an important role in the production and transaction process and provides structure to understanding (Aghion and Howitt 1992). Knowledge is different from information. Information is about facts and figures; however, knowledge is the understanding of the facts and figures (Morgan and Peha 2003). Many researchers (e.g. Thomas and Twyman 2004; Reed et al. 2007) also emphasize that both scientific knowledge (often held by experts) and social knowledge (such as the moral, ethical, political cultural, and

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behavioral dimensions of issues) particularly local ‘non-scientific’ knowledge (often held by non-experts) need to be integrated in combating desertification. Thus, the term ‘scholars’ as a broad concept includes professors, researchers, experts often technical persons who can use information to construct an expert–client relationship of influence (Rifkin and Martin 1997), and stakeholders who have assimilated the knowledge. For example, in the program of People’s Planning in the Kerala, India, a new ‘expert’ is defined broadly to include the ‘wise farmer’ in addition to the civil engineer (Fischer 2000).

The main objectives of this study are twofold: (i) to explore whether scholars’ participation plays an important role in combating desertification, and (ii) if so, how scholar-participated governance can be most effective to improve the outcome in combating desertification.

Research methods and data collection

We conducted a two-stage research project. In the first-stage, a field study was carried out in seven counties of northwest China (Figure 1) to gauge the significance of scholars’ participation in combating desertification and their different roles from 1949 to 2008. Among these seven representative counties, Zhongwei in Ningxia Hui Autonomous Region, known as the ‘capital of deserts’, is deemed the most successful case

in combating desertification in China. The other counties, Minqin, Jingtai, Linze, Jinta, Guazhou, and Dunhuang are all important oases in the Hexi Corridor in Gansu Province, whose capital is Lanzhou, the geographic center of the whole of China (Yang 2009). Minqin currently suffers the most serious desertification (Kang et al. 2008).

Following a random sampling strategy, a field survey was carried out from 26 June 2006 to 12 February 2008. Considering that some farmers might not be able to properly respond to questionnaires, the questionnaires were randomly distributed to students in different high schools, who were carefully trained to teach and help their family members. The reason why we do this is that many old farmers in villages cannot read Chinese characters. We received 1974 valid responses in total, with a response rate of more than 90% (Table 1a). In order to obtain more detailed information, 78 people (farmers, herders, scholars, government officials, businessmen, members of religious groups, NGOs) were also interviewed from 6 June to 31 July 2007 (Table 1b). For interviewees in the county seat, we contacted offices of the bureaus of the county, research institutes, schools, etc. to let them recommend interviewees. For interviewees in rural areas, we directly went to villages to find volunteers. The questions asked were consistent with questions in the survey questionnaires. For example, for the question whether scholars play an important role in

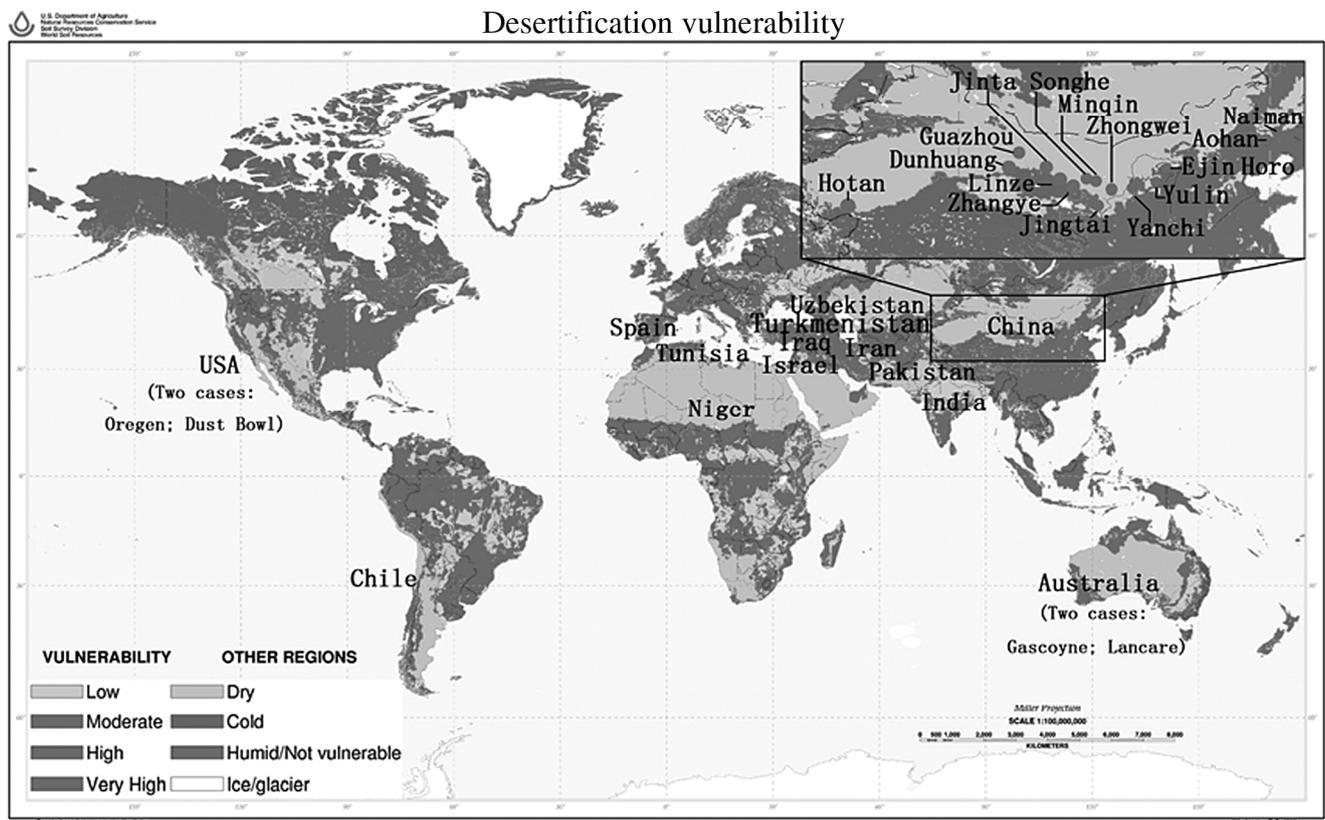


Figure 1. Global desertification vulnerability and case selection.

Note: This figure was adapted from the US Department of Agriculture, Nature Resources Conservation Service, Soil Survey Division, & World Soil Resources. 1998. Washington, DC. <http://soils.usda.gov/use/worldsoils/mapindex/desert.html>. County boundaries are not authoritative.

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Table 1. Survey and interview distribution in the seven counties.

(a) Survey distribution						
County	Number of sent copies	Response rates	Number of valid copies			
Zhongwei	300	0.95	280			
Minqin	370	0.92	322			
Jingtai	280	0.93	236			
Linze	250	0.96	239			
Jinta	300	0.93	260			
Guazhou	260	0.93	237			
Dunhuang	450	0.92	400			
Total	2210	0.93	1974			

(b) Interview distribution						
Counties and time	T	F	S	G	B	R
Minqin (6/6–7/13)	29	6	11	11	0	1
Zhongwei (7/20–7/22)	10	5	4	1	0	0
Jingtai (7/23–7/23)	9	3	3	3	0	0
Linze (7/24–7/26)	8	4	3	1	0	0
Jinta (7/27–7/28)	6	4	2	0	0	0
Guazhou (7/29–7/30)	8	6	2	0	0	0
Dunhuang (7/30–7/31)	8	1	2	1	4	0
Total	78	29	27	17	4	1

Note: T, total interviewees in this county; F, farmers, herders, other citizens; S, scholars; G, government officials; B, businessmen; R, members of religious groups or NGOs.

combating desertification, six choices in the survey questionnaires were given to evaluate scholars' participation – very important, important, moderately important, dispensable, negative, and unknown, while in random interviews people were given the same questions but without such choices in order to obtain their personal points of view.

Furthermore, in order to extend the survey and interview data, many archives (county annals, government gazettes from 1949 to 2007) and resources such as research reports, government documents, and historical memoirs from the seven counties were also collected. Detailed process-tracing and life-story analyses (Plummer 2001; George and Bennett 2005) of these archives were used to clarify the relationship between scholars' participation and the results of desertification control with scholars' participation and to explore the specific mechanisms of scholars' participation in combating desertification.

In the second stage of the study, in order to test causal generalizations, 23 cases (Figure 1) were also analyzed based on changing coverage, spatial extent, and cultural

contexts. Coverage, also called sampling density or intensity, means 'proportion of the study area or duration actually sampled' (Wu 2007, p. 118). Spatial extent refers to spatial span of a phenomenon or study or the study area (Wu 2007). Culture also plays an important role in forming institutions of governance. Ostrom (1997, p. 254) noted: 'The aspiration to achieve greater complementarities among the societies of mankind requires us to understand common features in our respective civilizations that might serve as common foundations'. Through changing cultural contexts, we wanted to study whether the findings in the seven Chinese counties still hold in other countries with different cultures. For coverage, five counties were chosen. Their locations, annual precipitation, representations (what they represented), and related literature are given in Table 2. For spatial extent, one village, Songhe in Minqin County, and two prefectures (between county level and provincial level), Yulin Prefecture in Shaanxi Province and Zhangye Prefecture (Linze is under its jurisdiction) in Gansu Province, were chosen. For cultural context, 15 cases from other 13 counties, Australia (two cases), Israel, Pakistan, Spain, Turkmenistan, USA (two cases), Chile, India, Iran, Iraq, Niger, Tunisia, Uzbekistan, in six different continents Africa, Asia, Australia, Europe, North America, and South America were chosen. Many archives, published articles, books, and reports were used to measure desertification severity and the results of problem resolving, and to evaluate whether the findings from the seven counties could be generalized.

Significance of scholars' participation

Among the six choices given to evaluate scholars' participation in the seven counties, more than 50% of the survey respondents indicated that scholars' participation in combating desertification was important (Table 3). That is, most respondents agreed that scholars played an important role in combating desertification. For the question whether the desertification condition had been ameliorated in their county after scholars' participation, the percentage of survey respondents who indicated 'yes' is shown in Table 3. The order, from least to highest of respondents in the six counties that thought desertification had been ameliorated by scholars' participation was consistent with the order (from the highest to the least) of the percentage of their desertified area (Li et al. 2003; Zhongwei was not included in this study) (Table 3).

Table 2. Five counties chosen by changing coverage.

County	Location	Precipitation	Representation	Literature
Hotan	Xinjiang Uygur Autonomous Region	34.8 mm	Extreme arid area in Taklimakan Desert	Zhao et al. 2003
Yanchi	Ningxia Hui Autonomous Region	300 mm	Desert steppe area in Mu Us sandy land	Zhao et al. 2003
Ejin Horo	Inner Mongolia Autonomous Region	340–400 mm	Transitional belt from semi-arid to arid areas in Mu Us sandy land	Zhao et al. 2004
Aohan	Inner Mongolia Autonomous Region	310–460 mm	Semi-arid pasturing area in Horqin Sandy Land	Teng and Dang 2003
Naimai	Inner Mongolia Autonomous Region	362 mm	Semi-arid farming-pasturing area in Horqin Sandy Land	Duffy and Migongo-Bake 2003; Zhao et al. 2003

Table 3. Scholars' impact and degree of amelioration as rated by survey respondents and desertification areas in the seven counties.

County evaluation	Zhongwei	Minqin	Jingtai	Linze	Jinta	Guazhou	Dunhuang
Scholars' impact	0.7250	0.5580	0.7235	0.7838	0.6372	0.6601	0.8092
Amelioration	0.2929	0.0000	0.1318	0.1799	0.1846	0.2996	0.0500
Percentage of desertified area	No Dada	0.5518	0.2108	0.1453	0.1324	0.9390	0.3445

Counties in which scholar's participation was high, however, did not mean that desertification amelioration by scholars' participation was also high. For example, in Dunhuang about 80% of respondents indicated that scholars' participation was important, but only about 5% of respondents agreed that desertification had been ameliorated. The relationship between desertification control and scholars' participation was complex. Many factors can simultaneously influence the results of desertification. For example, decreasing available surface water from about 500 million m³ in the 1950s to only 100 million m³ in recent years was an important reason for the serious desertification in Minqin County (Li and Chen 2001; Chen and Li 2002; Yang and Lan 2009). Government intervention and citizens' participation also might slow down or speed up the desertification process in these counties (Yang and Lan 2009). Therefore, in some areas, desertification would continue no matter how well the scholars did. Based on detailed discussions of process tracing for combating desertification in the seven counties through examining interview transcripts, survey answers, histories, and archival documents (George and Bennett 2005) and analyzing life-stories (Plummer 2001), we found that even when all these other factors were controlled, the mechanisms of scholars' participation in combating desertification were still discernable (for detailed analysis, please see Yang 2009). Also, the order of the net effect of desertification amelioration after controlling for non-scholar factors was consistent with the order based on respondents in the seven counties. This suggests that the ultimate impact of scholars' participation on the ground, to a large extent could be explained by the mechanisms of scholars' participation.

These findings are also consistent with the interview data. For example, in Minqin, several interviewed government officials and most scholars agreed that scholars played some roles in desertification control. One official argued that their work increased the name recognition of Minqin, leading the central government to dramatically increase investment. Furthermore, all 29 interviewees mentioned the severity of desertification and no interviewees mentioned amelioration, although there were a few scholars who mentioned that the severity of desertification in Minqin in fact was not as serious as described by local officials, who were likely to exaggerate its severity to get more government funds. All the interviewees in Minqin criticized the mechanisms of scholars' participation and scholars' behaviors in combating desertification. The main point was that although scholars did their research well, they often focused on their own research and pursuing their own interests, contributing little to local desertification control. In Zhongwei, however, the significance of scholars'

participation in combating desertification was highlighted by all interviewees. Also, interviewees highly praised the mechanisms of scholars' participation and scholars' behaviors in combating desertification, especially of scholars from the 1950s to the 1970s. For example, one scholar vividly recalled stories of several eminent Chinese scientists (e.g. Kezhen Zhu, Shen'e Liu, Yin Liu, Minggang Li, and Junzhao Ji) who made important contributions to combating desertification. One researcher argued that contemporary scholars' impact accounted for only about 30% of desertification control in Zhongwei County, while they accounted for at least 40–60% in the 1950s, 1960s, and 1970s. All 10 interviewees mentioned that present scholars did not help as much as their predecessors. Also, all 10 interviewees mentioned the activities of combating desertification during the 1950s–1970s, and said conditions have been greatly ameliorated because of scholars' significant and effective participation.

Seven design principles for successful scholar-participated governance

Based on combining analysis of the survey and interview data and archival documents, we found that seven factors differentiated scholars' participation in combating desertification in the seven counties, and relative importance of these seven factors was then ranked by survey respondents and interviewees (Table 4). The table shows that the higher (or longer) the levels of these factors are, the more successful scholars' participation in combating desertification will be. Through reanalyzing these seven factors, we synthesized a set of seven design principles (P1–P7) that characterized successful scholar-participated governance (Table 5). Further, these seven design principles were used to characterize all 30 cases in the research (Table 6). For each case, we indicate which of the seven design principles were clearly applied, which applied in a weak form, and which clearly not applied. We also characterized the achievements of scholars' participation in combating desertification into three classes: successful, semi-successful, and not successful. When the speed of desertification was significantly slowed by scholars' participation, the results of desertification control with scholars' participation were deemed 'successful;' when the speed of desertification increased, it was deemed 'unsuccessful;' and between these two types as 'semi-successful'. The results of scholars' participation in combating desertification in the seven counties in the first stage of the research were characterized through combing analysis of the net desertification amelioration, after controlling for non-scholar factors, and answers of respondents in the seven counties who thought desertification had been

Table 4. Comparing degree of related factors influencing scholars' participation in combating desertification and results in the seven counties as rated by survey respondents and interviewees.

County factors	Zhongwei	Linze	Jingtai	Guazhou	Jinta	Dunhuang	Minqin
F1. Significant participation of steady field-based scholars	H	M	H	M	M	M	L
F2. Federal organizational structure and concrete and stratified purposes	H	M	M	M	M	M	L
F3. Democratic and collaborative management with strictly implemented mechanisms of awards and sanctions	H	H	M	M	M	M	L
F4. Steady local scholar entrepreneurship	H	H	H	M	M	L	L
F5. Realization of expected benefits	H	S-H	S-H	M	M	L	L
F6. Experiment–extension governance method	H	M	H	M	L	L	L
F7. Reliable external resource support	H	S-H	S-H	L	M	L	L
Results	S	SE	SE	SE	SE	U	U

Note: H, high; S-H, semi-high; M, middle; L, low; NR, not relevant; S, successful; Se, semi-successful; U, unsuccessful.

Table 5. Design principles of successful scholar-participated governance.

Characteristics of scholars
P1. Significant participation of steady field-based scholars
Steady field-based scholars must be the key scholars and play an important role in governance
Characteristics of scholars' organizations and governance
P2. Federal organizational structure and concrete and stratified purposes
Scholars' organizations are mainly bottom-up federal structures, and have very concrete, organizational and stratified purposes
P3. Democratic and collaborative management with strictly implemented mechanisms of awards and sanctions
Practicing democratic and collaborative management, using almost consensus and face-to-face communication method at the grassroots level, and building selective incentive (including both awards and sanctions, but mainly positive) system with differing, graduated, federal types and multiple ways
P4. Steady local scholar entrepreneurship
Building steady local scholar entrepreneurship, no matter whether these scholars are originally local scholars, farmers, etc.
P5. Realization of expected benefits
Social actors' expected benefits can be realized, and their expectation can be reinforced with program development. As to environmental affairs, economic development and environmental protection can be combined
P6. The experiment–extension method
Practicing the method on experimental units and gradually extension of governance (abbreviated as experiment–extension governance, and in Chinese, Shidian-Tuiguang Governance)
For situations where external support is necessary
P7. Reliable external support
If external support (financial, technical, institutional, and spiritual) is necessary, it is steady or at least lasts a relatively long time until the system can build its own internal support mechanism, especially for financial, technical, and institutional support

ameliorated by scholars' participation. The results of scholars' participation in combating desertification in the 23 cases in the second stage of the research were evaluated by detailed discussions of process tracing in case studies through examining histories, archival documents, interview transcripts, and other sources, and analyzing life stories (Plummer 2001; George and Bennett 2005; Yang 2009). The conclusion was: the seven principles were all held when multiple coverage, spatial extent, and cultural contexts were addressed. No matter what the scale (larger or small), hierarchical level (high or low), and kinds of country and culture, the more the seven principles of scholar-participated governance were satisfied, the more successful was the intervention.

Principle 1

Scholars combating desertification may either be field-based or non-field-based (Yang 2007a, 2007b). The word 'field' here refers to a particular subject or a branch of knowledge on special problems such as combating desertification and

environmental protection. Also, 'field' refers to a particular geographic space or area. Together, we define field-based scholars as those who have lived or worked in the community for many years, know many things about the community, have good relationships with farmers, officials, and other social actors, and have enough field and local knowledge to resolve related problems such as desertification control and environmental protection. Our results showed that the longer the scholars stayed in a local site, the more successful their participation. Furthermore, the interviewees in the seven counties indicated that technical knowledge, knowledge about local conditions, and knowledge about local social relationships and webs were the three most important kinds of knowledge required in combating desertification, and the more they were integrated, the more successful the desertification control tends would be. This was also echoed by the survey data in the seven counties. Among 10 choices given to evaluate the importance of different kinds of knowledge in combating desertification, the respondents indicated that the two most important were (1) technical knowledge of

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Table 6. Satisfaction to seven principles and results of the 30 cases.

Case	Spatial extent	Temporal extent	P1	P2	P3	P4	P5	P6	P7	Result
A. The seven counties										
1. Zhongwei	County	1949–2007	Y	Y	Y	Y	Y	Y	Y	S
2. Linze	County	1949–2007	W	W	Y	Y	W	Y	Nr	SE
3. Jingtai	County	1949–2007	Y	W	W	Y	W	Y	Y	SE
4. Guazhou	County	1949–2007	W	W	W	W	W	Y	Nr	SE
5. Jinta	County	1949–2007	W	W	W	W	W	W	Nr	SE
6. Dunhuang	County	1949–2007	W	W	W	N	N	N	N	U
7. Minqin	County	1949–2007	N	N	N	N	N	N	N	U
B. The five counties by changing coverage										
8. Hotan County, Xinjiang	County	1949–2007	Y	Y	Y	Y	Y	Y	Y	S
9. Naiman Qi, Inner Mongolia	County	1949–2007	Y	Y	Y	Y	Y	Y	Y	S
10. Aohan Qi, Inner Mongolia	County	1949–2007	Y	Y	Y	Y	Y	Y	Nr	S
11. Yanchi County, Ningxia	County	1949–2007	W	W	W	W	W	Y	W	SE
12. Ejin Horo Qi, Inner Mongolia	County	1949–2007	Y	W	W	W	Y	Y	Y	SE
C. The three cases by changing spatial extent										
13. Songhe Village, Minqin County	Village	1949–2007	Y	Y	Y	Y	Y	Y	Y	S
14. Yulin Prefecture, Shaanxi	Prefecture ^a	1949–2007	Y	W	W	W	Y	Y	Y	SE
15. Zhangye Prefecture, Gansu	Prefecture	1949–2007	N	N	N	N	N	N	N	U
D. The 15 cases by changing cultural context										
16. The Landcare Program, Australia	National	1989–2007	Y	Y	Y	Y	Y	Y	Y	S
17. The Negev Case, Israel	Provincial ^b	1948–2007	Y	Y	Y	Y	Y	Y	Y	S
18. Mona Reclamation Experimental Project, Pakistan	Prefecture	1965–2007	W	W	W	W	Y	W	Y	SE
19. The ‘LUCDEME’ Project, southeast Spain	Provincial	1981–2007	W	W	W	W	W	W	Y	SE
20. Integrated Desert Development and Desertification Control, Turkmenistan	National	1924–2007	W	W	W	W	W	W	W	SE
21. The Vale Rangeland Rehabilitation Program, Oregon, USA	County	1962–2007	W	Y	Y	Y	Y	Y	Y	SE
22. The Dust Bowl Case, USA	Provincial	1932–2007	W	Y	Y	W	Y	Y	W	SE
23. The Gascoyne Basin, Australia	Provincial	1876–1980	N	N	N	N	N	N	N	U
24. The Region of Coquimbo, Chile	Provincial	1900–1980	N	N	N	N	N	N	N	U
25. The Luni Development Block, Rajasthan, India	Prefecture	1900–1982	N	N	N	N	N	N	N	U
26. The Turan Program, Iran	Provincial	1975–1984	N	N	N	N	N	N	N	U
27. The Greater Mussayeb Project, Iraq	Provincial	1953–1980	N	N	N	N	N	N	N	U
28. The Eghazer and Azawak Region, Niger	Prefecture	1900–1970s	N	N	N	N	N	N	N	U
29. The Oglat Mertebe Region, Tunisia	Prefecture	1900–1980s	N	N	N	N	N	N	N	U
30. The Golodnaya Steppe, Uzbekistan	Provincial	1869–1980	N	N	N	N	N	N	N	U

Note: Y, yes; N, no; W, weak; Nr, not relevant; S, successful; SE, semi-successful; U, unsuccessful. ^aPrefecture means this case was in an area larger than a county and smaller than a province or state in the country. ^bProvincial means this case was in a province or state or within several provinces or states.

desertification and dust storms, and (2) particular knowledge in understanding the local problems of desertification and dust storms (evaluated by percentage of respondents) (Table 7a). Among 14 choices on disadvantages of scholars' participation in combating desertification, more than 24% of respondents in the seven counties indicated that lack of regard for local conditions was the most important disadvantage (Table 7b). Also, among the 14 choices of scholars' disadvantages, the percentage of respondents

unaware of local social relationships and webs in Linze, Jinta, Dunhuang, and Minze were above average (0.071); in Jingtai, it was close to average (0.070) (Table 7c).

The effectiveness of local field-based scholars in combating desertification seemed to be determined by six factors: (i) relatively independent social identity and high social status; (ii) high enthusiasm and capability; (iii) adequate readily understandable hands-on knowledge; (iv) high social capital in relation to other social actors;

Table 7. The three most important kinds of knowledge as rated by survey respondents.

County	Zhongwei	Linze	Jingtai	Guazhou	Jinta	Dunhuang	Minqin
(a) The two most important kinds of knowledge							
Technical knowledge	0.375	0.352	0.364	0.307	0.400	0.265	0.370
Local conditions	0.300	0.372	0.287	0.253	0.246	0.290	0.335
(b) Not knowing local conditions							
Percentages	0.325	0.289	0.275	0.320	0.254	0.245	0.326
(c) Not knowing local social relationships and webs							
Percentage	0.057	0.167	0.070	0.037	0.100	0.096	0.103

(v) high social responsibility; and (vi) respect for other social actors and local knowledge. These can be considered as six sub-principles of Principle 1. For example, we found all six sub-principles were satisfied in Zhongwei County, especially during the 1950s–1970s. In Minqin, although scholars had relatively independent social identity and high social status and also relatively sufficient, easily understood, and hands-on knowledge, they did not satisfy the other sub-principles. Thus, even if the study of combating desertification made by these scholars was famous in China, they did not contribute much to practical activities in combating desertification in Minqin.

In the Landcare program in Australia, Landcare groups as local voluntary groups comprised of land users in rural areas can be deemed steady field groups. Many leading farmers and conservationists who played a key role in design, implementation and interpretation of research and development projects were included in Landcare groups. Through them, the extension, research, and development was made less linear, scientists were put in more direct contact with the community, the boundary between extension and research was dissolved, and practical experience and local knowledge were better used (Campbell 1992). They had relatively independent social identity. Because they often earned higher cash income, had higher levels of debt, and undertook more land conservation practices than other farmers, they also had relatively higher social status. As far-sighted people, particularly often as activists and conservationists, they are concerned more with the future. As more active seekers of information, they not only had knowledge advantages over farmers but also acted as advisers of the farmers (Campbell 1992), legitimate players in research (Chambers et al. 1989), and were more aware, informed, skilled, and adaptive resource managers (Curtis and Lacy 1996). Mature Landcare groups could gain credibility, which formed their social capital. After groups were formed, they often grew quickly and developed on-going relationships with local and state government agencies, local businesses, community groups (including neighboring Landcare groups), universities, researchers and consultants, scholars, and other landholders. Also, Landcare groups often had high social responsibility in their own district, could influence others and could gain respect from other social actors (Campbell 1992).

In the Negev case in Israel, Michael Evenari and his team are a good example of field-based scholars. Although they were professors or researchers, they carefully studied the history and other problems of the Negev and stably developed a program and stayed in the field (Evenari 1989). Furthermore, universities such as Ben Gurion University in the Negev at Beer Sheva made a considerable contribution to educate and supply steady field scholars for this region (Scheckter and Galai 1980).

Principle 2

A federal group is a federation of a number of small groups, each of which may be induced to use its social incentives to

get its members to contribute toward the collective goals of the whole group when the federated organization provides some service to them (Olson 1971). The organizational purpose may be a conceptual purpose that is very abstract and mainly focuses on values, and may also be a concrete purpose that is relatively material and instrumental and can be used as a tool to pursue a more conceptual purpose. Successful scholar-participated governance must have practical and feasible concrete purposes that can be used as tools to realize its conceptual and abstract purposes. For example, the purposes to protect the Yellow River and Lanzhou–Xinjiang Railroad in Zhongwei and to protect the Jingdian Pumping Irrigation Project in Jingtai are more concrete than the purposes to combat desertification and protect the environment in Minqin.

The Vale rangeland rehabilitation program in Oregon is also a good example satisfying this principle. It divided the district into three resource areas, which were further broken down into 14 planning units. Although the final authority for the coordinated program rested with the district manager, the area managers exercised considerable autonomy in initiating planning and site selection for improvement projects. Concrete objectives of the Vale program were correcting erosion accompanying downstream sedimentation, preventing further soil loss, increasing forage supply for wildlife and livestock, stabilizing the livestock industry at the present or an increased level of production, etc. (Heady 1988).

In the Turan program in Iran, this principle was not satisfied, however, because its management was authoritarian and controlled by government, thus its organizational structure was centralized (Department of the Environment 1980). The traditional and rural world was also distrusted and ignored. Martin (1982) even argued that the lack of communal organization contributed a lot to environmental destruction in Turan and he carefully studied its reasons. Also, the organizational purpose was not very concrete and often led to contradictory results (Department of the Environment 1980).

Principle 3

Democratic institutional arrangements should be applied in scholars' participation in governance, and almost consensus and face-to-face communication method should be used in the decision-making process, especially at grassroots level. The collaboration among local social actors (such as farmers, scholars, and government officials) and the collaboration between local social actors and non-local social actors (such as outside scholars, governments, and NGOs) are important in combating desertification. Furthermore, participatory and collaborative research (Fischer 2000) should be encouraged. Both awards and sanctions as selective incentives should be used, although these should be mainly positive (Olson 1971) and graduated (Ostrom 1990) to form a federal system with multiple choices. For example, the Vale program paid much attention to favorable public opinion, the need for effective publicity, and information from a majority of respondents (Government of the United States of America 1980; Huntsinger and Heady 1988).

Considerable autonomy exercised by the area managers also indicated its democratic style (Heady 1988). The cooperation among different resource areas and different managers, between the BLM (Vale district of the Bureau of Land Management) and Congress, and among the BLM, community members, program area permittees, and environmentalists, demonstrated the collaborative management of the Vale program (Heady 1988; Huntsinger and Heady 1988). In this program, monitoring of grazing use was the joint responsibility of the BLM and the permittees. As Huntsinger and Heady (1988, p. 63) pointed out:

The BLM monitors yearly compliance with season of use and stocking levels, but changes are based primarily on measured levels of forage utilization and changes in range condition on permanent plots (BLM 1984). The permittee of the 1980's is given much leeway in day-to-day compliance with grazing plans.

In China, the Hotan County case, Naiman Banner case, Aohan Banner case, and Songhe Village case are all good examples of meeting Principle 3. For instance, in Naiman, local participation, community-based governance, farmers' voluntary participation, and local and international collaboration (UNEP 2002; Carle and Ma 2005; Kim et al. 2006) demonstrated that democratic and collaborative management was applied effectively. Furthermore, many scholars (e.g. Xu 1995; Wang 2003) also pointed out that the federal mechanism of awards and sanctions was also built.

Principle 4

Scholars can be entrepreneurs for farmers, local communities, businesses, and other social actors (Olson 1971; Yang 2007a; Yang and Wu 2009). This study found that although both local scholars and outside scholars may be able to help, it is only local scholars who can be most effective. Furthermore, only local scholars can have high scholar entrepreneurship and finally become real scholar entrepreneurs, but outsiders should not be true leaders. If outsider scholars temporarily become leaders, they should democratically help local people have their local leaders and construct alliances with them. For example, in the Landcare program in Australia, Campbell (1992, p. 16) argued that in the phase of maturity, Landcare groups as local actors had 'settled down, with easy identification of leaders and future leaders, talkers, workers, followers, sleepers, and hangers-on'. Also, he pointed out that the major difference between effective groups and ineffective groups was whether they had good leaders.

In Zhongwei County in China, at the beginning of the program, because many scholars in Zhongwei Experimental Station on combating desertification came from other counties or provinces, even if they had much scientific knowledge of combating desertification, they could not get enough support from local farmers and become the real leaders. Then they tried very hard to build good relationships with the local farmers and their leaders, teach them, and help them finally find their own scholar entrepreneurs.

Some scholars also transferred to be local scholar entrepreneurs after they had lived in the county for many years. Furthermore, scholars' leadership was a kind of shared leadership that focused on clusters of individuals working and growing together, rather than on the leader (Denhardt et al. 2002).

Principle 5

Social actors' expected benefits can be realized, and their expectation can be reinforced with program development. Furthermore, economic development and environmental protection should be combined. For example, according to our field studies, we found that Zhongwei is a case that combined both very well through the firms' participation in combating desertification, while Minqin and Dunhunag are two failure cases that mainly focused on economic development and finally destroyed the environment.

In the Landcare program, in addition to soil conservation, conservation farming, farm planning, revegetation, land protection, vermin and weed control, and river management, land users in Landcare groups and other social actors only worked when a change in interests or benefits to the people was deemed desirable, and effective Landcare groups must overcome any difficulty, even when there is a lack of evidence of immediate benefits to social conservation (Campbell 1992). In the Negev case in Israel, the use of advanced agricultural techniques and development of technological innovations decreased the amount of water used per unit production, and this not only reduced production costs and raised the farmers' profits but also freed water for additional production (Scheckter and Galai 1980).

Principle 6

The fundamental rule of the experiment-extension method was that social actors first do experiments in relatively small areas or zones and extend them gradually to broader areas after obtaining sufficient experience. The more complex and the newer the problem, the more useful is this method. If some new and untested methods are rashly used in a large area, the cost will be very high, or even unaffordable if they fail. For example, in Naiman in China, the Institute of Desert Research (IDR), Chinese Academy of Sciences, undertook a project from 1986 to 1995 that involved three distinct phases: 'an experiment conducted in a research station to study desertification mechanisms and to design strategies for their control, implementation of experimentally proven interventions in the demonstration village, and encouraging the implementation of successful interventions in other nearby villages' (Duffy and Migongo-Bake 2003, p. 69). The same characteristics of other projects in this area have also been argued by many other researchers (e.g. UNEP 2002; Zhao et al. 2006).

In the Negev program in Israel, based on experiments, the Evenari team reconstructed two ancient Nabatean farms and 'succeeded in obtaining excellent yields of grain, fruits, vegetables, pasture and other crops' (Scheckter and Galai

1980, p. 270). The same group also developed a system of individual micro-catchments, and then a large area was established for wider-scale experimentation. Many other experiments were also done to resolve problems such as water desalination, rainfall enhancement, arid zone irrigation with brackish water, as well as agricultural technology for the semi-arid zone, and then the successful technologies and methods were extended later (Scheckter and Galai 1980).

Principle 7

In a self-supported system that can realize its proposed development and desertification control without external help, scholar-participated governance can be successful when the aforementioned six principles apply. For a non-self-supported system, steady external support is necessary. 'Steady' here means that support should at least last until a self-supported mechanism is built. Four kinds of external support – financial, technical, institutional, and moral – were found important in the Landcare program in Australia. Campbell (1992, p. iii) argued: 'It is simply unfair and totally unrealistic to expect voluntary groups of people, even if there were 100,000 active Landcare members, to fix land degradation or develop more sustainable farming systems without a significant external support – financial, technical, institutional and moral'.

Similarly, analysis of other cases also indicated this, especially the first three kinds of support. For example, our field study indicated that because of protecting the Yellow River and Lanzhou–Xinjiang Railroad in Zhongwei and protecting the Jingdian Pumping Project in Jingtai, these two counties got significant external support, while the Minqin and Dunhuang cases did not. In the Aohan Banner case in China, except for local scholars, participation of outside scholars guaranteed steady external technical and knowledge support for Aohan Banner. External financial support from provincial, central government of China, other counties, the UN, etc. guaranteed its steady external financial support. Furthermore, support from the prefecture, provincial and central government guaranteed steady external institutional support (Wang 2003; McGarry 2005).

Conclusion

This study found that scholars play an important role in combating desertification globally and that successful scholar-participated governance should meet seven design principles. These seven principles embody essential elements or conditions that help to account for the success of scholar-participated governance in combating desertification. From a policy perspective, these seven principles also provide some concrete instructions to promote scholar participation, to transform unsuccessful or semi-successful participation into more successful participation, and to design new institutions for scholar participation in combating desertification. We do not claim that these principles cover all aspects or elements of successful scholar-participated governance in combating desertification, although we feel they are

essential and core elements. Furthermore, whether these principles can be replicated in other fields besides desertification control should be further studied in the future.

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References

- Aghion P, Howitt P. 1992. A model of growth through creative destruction. *Econometrica*. 60(2):323–351.
- Betsill MM, Corell E. 2008. NGO diplomacy: the influence of nongovernmental organizations in international environmental negotiations. Cambridge (MA): MIT Press.
- [BLM] Bureau of Land Management. 1984. Rangeland monitoring: utilization studies. BLM Tech. Ref. Colorado (USA): Denver Service Center.
- Campbell A. 1992. Landcare in Australia: taking the long view in tough times. Third annual report. Canberra: National Soil Conservation Program.
- Carle J, Ma Q. 2005. Challenges of translating science into practice: poplars and other species in the three North Region of China. *Unasyuva*. 221(56):31–37.
- Chambers R, Pacey A, Thrupp L. 1989. Farmer first – farmer innovation and agricultural research. London: Intermediate Technology Publications.
- Chen JH, Li JJ. 2002. Research on environmental reconstructing in Minqin County, Gansu Province. *J Lanzhou Univ (Nat Sci)*. 38(3):103–108.
- Curtis A, Lacy TD. 1996. Landcare in Australia: does it make a difference? *J Environ Manage*. 46(2):119–137.
- Denhardt RB, Denhardt JV, Aristigueta MP. 2002. Managing human behavior in public and nonprofit organizations. Thousand Oaks (CA): Sage Publications.
- Department of the Environment. 1980. The Turan programme. In: Biswas MR, Biwas AK, editors. Desertification: associated case studies prepared for the United Nations conference on desertification. Oxford: Pergamon Press. p. 81–251.
- Duffy P, Migongo-Bake E. 2003. The application of EIA in the evaluation of sustainable desertification control activity: examples from Namibia and Inner Mongolia. *Impact Assess Proj Appraisal*. 21(1):65–74.
- Evenari M. 1989. The awakening desert: the autobiography of an Israeli scientist. Berlin: Springer-Verlag.
- Fan S, Zhou L. 2001. Desertification control in China: possible solutions. *Ambio*. 30(6):384–385.
- Fischer F. 2000. Citizens, experts, and the environment: the politics of local knowledge. Durham and London: Duke University Press.
- Fullen MA, Mitchell DJ. 1994. Desertification and reclamation in North-Central China. *Ambio*. 23(2):131–135.
- George AL, Bennett A. 2005. Case studies and theory development in the social sciences. Cambridge: MIT Press.
- Glenn E, Smith MS, Squires V. 1998. On our failure to control desertification: implications for global change issues, and a research agenda for the future. *Environ Sci Policy*. 1(2):71–78.
- Government of the United States of America. 1980. Vale rangeland rehabilitation programme, Oregon. In: Mabbutt JA, Flotet C, editors. Case studies on desertification. Paris: UNESCO. p. 269–272.

- GTZ. 2005. Fact sheet desertification: Africa. Convention project to combat desertification. Eschborn (Germany): GTZ; [cited 2005 Dec 2]. Available from: http://www.2gtz.de/desert/download/basicfactsheets/factsheet_africa.pdf.
- Heady HF. 1988. The Vale rehabilitation program. In: Heady HF, editor. The Vale rangeland rehabilitation program: an evaluation (Pacific Northwest Research Station Resource Bulletin PNW-RB-157). Portland or USA: US Department of the Interior, Bureau of Land Management and US Department of Agriculture, Forest Service. p. 20–35.
- Huang S, Siegert F. 2006. Land cover classification optimized to detect areas at risk of desertification in North China based on SPOT VEGETATION imagery. *J Arid Environ.* 67(2):308–327.
- Huntsinger L, Heady H. 1988. Perceptions of the Vale program. In: Heady HF, editor. The Vale rangeland rehabilitation program: an evaluation (Pacific Northwest Research Station Resource Bulletin PNW-RB-157). Portland or USA: US Department of the Interior, Bureau of Land Management and US Department of Agriculture, Forest Service. p. 103–133.
- Kang S, Su X, Tong L, Zhang J, Zhang L, Davies WJ. 2008. A warning from an ancient oasis: intensive human activities are leading to potential ecological and social catastrophe. *Int J Sustain Dev World Ecol.* 15(5):440–447.
- Kim ES, Park DK, Zhao XY, Hong SK, Koh KS, Suh MH, Kim YS. 2006. Sustainable management of grassland ecosystems for controlling Asian dusts and desertification in Asian continent and a suggestion of Eco-village study in China. *Ecol Res.* 21(6):907–911.
- Li X, Chen G, Qu J, Chen H, Wang X. 2003. Desert and desertification of desert grassland zone. In: Wang T, editor. Desert and desertification in China. Shijiazhuang: Hebei Science and Technology Publishing House. p. 595–639.
- Li YC, Chen FH. 2001. Water resource sustainable utilization countermeasures in Minqin basin of Gansu province. *J Mt Sci.* 19(5):465–469.
- Martin MA. 1982. Conservation at the local level: individual perceptions and group mechanisms. In: Spooner B, Mann, HS, editors. Desertification and development: dryland ecology in social perspective. New York: Academic Press. p. 145–169.
- McGarry D. 2005. The 'current status' of conservation agriculture in China: a report for the People's Republic of China/Global Environmental Facility (OP12)/Asian Development Bank 'Partnership on Land Degradation in Dryland Ecosystems' (first draft) [Internet]. Manila (the Philippines): Asian Development Bank; [cited 2008 Jan 20]. Available from: http://www.gadb.org/Projects/PRC_GEF_Partnership/current-status.pdf.
- [MEA] Millennium Ecosystems Assessment. 2005. Ecosystems and human well-being: desertification synthesis. Washington (DC): World Resources Institute.
- Morgan MG, Peha JM. 2003. Science and technology advice for congress. Washington (DC): Resources for the Future.
- Olson M. 1971. The logic of collective action: public goods and the theory of groups. Cambridge (MA): Harvard University Press.
- Ostrom E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge (UK): Cambridge University Press.
- Ostrom V. 1997. The meaning of democracy and the vulnerability of democracies: a response to Tocqueville's challenge. Ann Arbor (MI): The University of Michigan Press.
- Plummer K. 2001. Documents of LIFE 2: an invitation to a critical humanism. London, Thousand Oaks and New Delhi: Sage Publications.
- Rasmussen K, Fog B, Madsen JE. 2001. Desertification in reverse? Observations from northern Burkina Faso. *Glob Environ Change.* 11(4):271–282.
- Reed MS, Dougill AJ, Taylor MJ. 2007. Integrating local and scientific knowledge for adaptation to land desertification: Kalahari rangeland management options. *Land Degrad Dev.* 18:249–268.
- Reynolds JF, Smith DMS, Lambin EF, Turner BL, Mortimore M, Batterbury SPJ, Downing TE, Dowlatabadi H. 2007. Global desertification: building a science for dryland development. *Science.* 316:847–851.
- Rifkin WD, Martin B. 1997. Negotiating expert status: who gets taken seriously. *IEEE Technol Soc Mag.* 16(1):30–39.
- Scheckter Y, Galai C. 1980. The Negev – a desert reclaimed. In: Biswas MR, Biwas AK editors. Desertification: associated case studies prepared for the United Nations Conference on Desertification. Oxford (NY): Pergamon Press. p. 255–308.
- [CCICCD] Secretariat of China National Committee for the Implementation of the United Nations Convention to Combat Desertification. 2002. China national report to implement the United Nations Convention to Combat Desertification (UNCCD). Beijing (China): CCICCD; [cited 2008 Mar 10]. Available from: http://www.unccd.int/cop/reports/asia/national/2002/china_eng.pdf.
- Sheehy DP. 1992. A perspective on desertification of grazing land ecosystems in North China. *Ambio.* 21(4):303–307.
- Skuras D, Dimara E, Vakrou A. 2000. The day after grant-aid: Business development schemes for small rural firms in lagging areas of Greece. *Small Bus Econ.* 14(2):125–136.
- Stringer LC. 2008. Reviewing the international year of deserts and desertification 2006: what contribution towards combating global desertification and implementing the United Nations convention to combat desertification? *J Arid Environ.* 72(11):2065–2074.
- Teng X, Dang Y. 2003. Technology for transforming low-yield poplars forest in loess hill and sandy land. *Inner Mong For Invest Des.* 3:60–62.
- Thomas DSG. 1997. Science and the desertification debate. *J Arid Environ.* 37(4):599–608.
- Thomas DSG, Twyman C. 2004. Good or bad rangeland? Hybrid knowledge, science, and local understandings of vegetation dynamics in the Kalahari. *Land Degrad Dev.* 15(3):215–231.
- Tschakert P. 2007. Views from the vulnerable: understanding climatic and other stressors in the Sahel. *Glob Environ Change.* 17(3–4):381–396.
- [UN] United Nations. 1992. Managing fragile ecosystems: combating desertification and drought, chapter 12 of agenda 2. New York (NY): United Nations.
- [UNCCD] United Nations Convention to Combat Desertification. 1994. Elaboration of an international convention to combat desertification in countries experiencing serious drought and/or desertification, particularly in Africa (U.N. Doc. A/AC.241/27, 33 I.L.M. 1328). New York (NY): United Nations.
- [UNEP] United Nations Environment Programme. 2002. Increasing productivity on fragile soils: comprehensive desertification control using sustainable moisture conservation, crops and animal husbandry technologies in Naimanqui Banner County, China. In success stories in the struggle against desertification: a holistic and integrated approach to environmental conservation and sustainable livelihoods [Internet]. Geneva (Switzerland): UNEP; [cited 2008 Jan 10]. Available from: <http://www.unep.org/desertification/successstories/SSS%20Evaluation%20report%20.pdf>.
- [UNEP] United Nations Environmental Programme. 2003. Global environmental outlook 3 [Internet]. Geneva (Switzerland): UNEP; [cited 2008 Mar 10]. Available from: www.unep.org/geo/geo3/english.
- Verón SR, Paruelo JM, Oesterheld M. 2006. Assessing desertification. *J Arid Environ.* 66(4):751–763.
- Wang GJ. 2003. Zhili huangmohua de chenggong moshi—Neimenggu Aohan Qi shengtai huangjing jianshe huigu [Internet]. Aohan, Inner Mongolia: Neimenggu Aohan Qiwei Xuanchuanbu; [cited 2008 Jan 15]. Available from: <http://www.aohan.gov.cn/html/cgms.htm>.
- Wang X, Chen F, Dong Z. 2006. The relative role of climatic and human factors in desertification in semiarid China. *Glob Environ Change.* 16(1):48–57.

- Wu J. 2001. Desertification. In: Robinson R, editor. *Plant sciences for students*. New York: Macmillan Reference. p. 70–73.
- Wu J. 2005. A new paradigm for a transdisciplinary science of desertification. *Divers Distrib.* 11(4):362–363.
- Wu J. 2007. Scale and scaling: a cross-disciplinary perspective. In: Wu J, Hobbs RJ, editors. *Key topics in landscape ecology*. Cambridge (UK): Cambridge University Press. p. 115–142.
- Xu DW. 1995. Naiman Qi guoyou linchang (pu) gaige jian cheng-xiao. *J Inner Mong For.* 8:17–18.
- Yang L. 2007a. Scholar-based governance: a fourth model for collective action. *Chin Public Adm.* 259(1):96–103.
- Yang L. 2007b. Building a multi-collaborative community governance system to resolve the dilemma of collective action: a framework of ‘product–institutional’ analysis (PIA). *J Public Manage.* 4(2):6–23.
- Yang L. 2009. *Scholar-participated governance: combating desertification and other dilemmas of collective action* [dissertation]. Phoenix (AZ): Arizona State University.
- Yang L, Lan Z. 2009. The issue of problem formulation in public policy-making – a sandstorm-combating policy case in north China. Albuquerque, New Mexico: 51st Annual Western Social Science Association (WSSA) Conference.
- Yang L, Wu J. 2009. Scholar-participated governance as an alternative solution to the problem of collective action in social–ecological systems. *Ecol Econ.* 68(8–9):2412–2425.
- Yang X, Zhang K, Jia B, Ci L. 2005. Desertification assessment in China: an overview. *J Arid Environ.* 63(2):517–531.
- Zha Y, Gao J. 1997. Characteristics of desertification and its rehabilitation in China. *J Arid Environ.* 37(3):419–432.
- Zhang K, Li X, Zhou W, Zhang D, Yu Z. 2006. Land resource degradation in China: analysis of status, trends and strategy. *Int J Sustain Dev World Ecol.* 13(5):397–408.
- Zhao C, Chen G, Zhang T, He X. 2003. Sand hazard and engineering. In: Wang T, editor. *Desert and desertification in China*. Shijiazhuang: Hebei Science and Technology Publishing House. p. 816–876.
- Zhao HL, Zhou RL, Zhang TH, Zhao XY. 2006. Effects of desertification on soil and crop growth properties in Horqin sandy cropland of Inner Mongolia, north China. *Soil Tillage Res.* 87(2):175–185.
- Zhao L, Chen H, Bai X. 2004. Evaluation of ecological service value of soil and water conservation based on GIS technology in Yijinhuoluo County. *Soil Water Conserv China.* 7: 20–22.