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Roles of Scholars in the Practice of Combating-Desertification: A Case Study in Northwest China

Lihua Yang · Zhiyong Lan · Jianguo Wu

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Abstract This study investigated the perceived importance of scholars' participation in combating-desertification programs in northwest China and analyzed the underlying factors and mechanisms. Our results show that, while various experts, professors, and researchers have participated in combating-desertification programs, their actions were often not effective. Only those scholars who understood the local situations adequately had important and positive impacts. These scholars served as information brokers between the governments and other stakeholders, entrepreneurial activity organizers for farmers, governmental representatives, or advocators for local affairs themselves. They played indispensible roles in facilitating efforts in combating desertification. The study also identified key factors that led to the success of scholars' participation in combating-desertification activities. Our findings have practical implications for improving the effectiveness of scholars' participation in land restoration and environmental management.

Keywords Combating desertification · Scholars' participation · Land amelioration · Mechanisms of scholars' participation · Environmental management

L. Yang (✉)
School of Public Administration, Beihang University,
No. 37 Xueyuan Rd, Beijing 100191, China
e-mail: Lihua.yang@asu.edu; journeyyang@yahoo.com.cn

Z. Lan
School of Public Affairs, Arizona State University, 3720 411,
North Central Avenue, Ste. 450, Phoenix, AZ 85004-0687, USA

Z. Lan
School of Public Administration, Renmin University
of China, Beijing, China

J. Wu
School of Life Sciences and Global Institute of Sustainability,
Arizona State University, Tempe, AZ, USA

J. Wu
Sino-US Center for Conservation, Energy, and Sustainability
Science, Inner Mongolia University, Hohhot 010021, China

Introduction

Desertification refers to land degradation or the spread of desert-like conditions in arid, semi-arid, and dry sub-humid regions, resulted primarily from human land use activities and climate change (Taddese 2001; UN 1992; Wu 2001, 2005). As one of the greatest environmental challenges of our times, desertification has been studied by researchers in a wide range of disciplines (Davis 2005; Lindskog and Tengberg 1994; Reed and others 2007; SACDS 1977; Seely 1998; Stringer and Reed 2007; Thomas 1997; Thomas and Twyman 2004). However, few have studied the roles that scholars may play in combating desertification (Yang 2009; Yang and Wu 2009, 2010). Based on a game theoretical analysis in collective action, Yang and his colleagues (Yang 2007a, b, 2009; Yang and Wu 2009) argued that scholars who have comparative advantages in knowledge could play an important role in the collective action of combating desertification. Scholars can play at least six kinds of roles: information providers for governments and farmers or herders; entrepreneurial activity organizers (for farmers or herders); self-interest defenders; representative agents of the governments; representative agents of firms with stakes; and representative agents of NGOs and other groups involved.

The term, "scholar," here is defined in accordance to the traditional Chinese concept—"shi" (±)—a respected

learned person (someone with knowledge and recognized social status). According to this definition, professors, experts, technicians, and local people with self-learnt knowledge for combating desertification (maybe called "indigenous scholars") are all scholars. Based on Yang and Wu (2009), this current study attempts to address the following research questions: (1) Does scholars' participation in combating desertification make any difference? (2) How can scholars' participation in combating desertification be more effective? To address these scientific questions, we conducted a series of analyses based on empirical data collected from northwestern China.

Study Area and Research Methods

Site Selection

The seven counties of this study constitute the central part of the geographically well-known "Hexi Corridor" in northwestern China. These counties have a long history of combating desertification with scholars' participation and share similar geophysical, climatic, and ecological conditions (see Fig. 1). Among the seven counties, Zhongwei in Ningxia Province is often deemed as one of the most successful cases in combating desertification in China (Wang 2003; Yang 2009), while Minqin in Gansu Province is still suffering the most serious desertification (Li and others 2003; Yang 2009). Located in the arid and semiarid region, the study area has an annual average temperature of 4–12°C, annual average precipitation of 100–200 mm, and population density of smaller than 100 persons per square kilometer (AXBW 1992; DSBW 1994; JDBW 1992; JXBW 1996; LXBW 2001; MXBW 1994; ZXBW 1995). The major physical erosive force in this area is wind, and land conversion and groundwater pumping for agriculture have been considered an important cause of desertification (see CCICCD 2000, 2002).

Fig. 1 The seven research sites and jurisdictions

Site Descriptions

Based primarily on the documented histories of counties (AXBW 1992; DSBW 1994; JDBW 1992; JXBW 1996; LXBW 2001; MXBW 1994; ZXBW 1995), we provide a concise description for each study site as follows.

Zhongwei is located at 104°17′–105°37′E, 36°59′–37°42′N with a total area of 5,780 km^2 and a population of 348,276 in 2005 (ZTNB 2006). Since Qin (221 BC–206 BC) and Han (206 BC–202 AD) Dynasties, along with land reclamation, more and more forests have been destroyed, and more and more land has been desertified. Its two local organizations, Center for Sanddune Fixation and Forestry established in 1954 and Shapotou Desert Experimental Research Station founded in 1955, have played an important role in combating desertification since the 1950s. Also, in order to protect the Lanzhou–Xinjiang Railroad and Yellow River, both the central and local governments have constantly pumped into the area financial and technical support since the 1950s.

Jingtai is located at 103°33′–104°43′ E, 36°43′–37°38′ N with a total area of 5,483 km^2 and a population of 230,000 in 2004. It has also suffered desertification problems for many years because of land reclamation and groundwater pumping for irrigating crops. In order to protect the Jingdian Pumping Irrigation Project, many local people have been involved in desertification control since the 1990s. The main purpose of Jingtai Desert Control Station, jointly Founded by Gansu Desert Control Research Institute (GDCRI) and the government of Jingtai County in 1992, is to conduct experiments on desert control in the area of the Jingdian Pumping Irrigation Project (GDCRI 2009a). Because of this project, they have also received plenty of support from the local and central governments since 1992.

Minqin is located at 102°45′–103°55′ E, 38°20′–39°10′ N with a total area of 16,000 km^2 and a population of 307,200 in 2004. It is typical of many of the desert-oasis counties of inland China with a combination of pastoral and agricultural production regimes. During the past six decades, especially in the past three decades, it has become one of the driest places nationwide and one of the most seriously affected regions by desertification in China (Yang 2009). Due to its history and location, the farmers themselves have invented many local desertification combating methods. Minqin Integrated Desert Control Experimental Station is one of the six county-level desert control stations founded in

1959 by the Desert Control Expedition of Chinese Academy of Sciences (CAS) in northwestern China and has been under the leadership of the Gansu Forestry Department since 1978 (GDCRI 2009b).

Linze is located at 99°51′–100°30′ E, 38°57′–39°42′ N with a total area of 3,148 km^2 and a population of around 150,000 in 2004. As one of the three most desertified counties (Gaotai, Jinta and Linze) due to land reclamation in Jiuquan Prefecture in Gansu, Linze has suffered from desertification for many years. Founded in 1987 by Linze County itself, Linze Desert Control Station, whose main functions are to demonstrate and extend desert control technologies (GDCRI 2009c), began cooperating with GDCRI in 1991 and finally became one of its permanent fields of experimental bases in 2002.

Jinta is located at 97°58′–100°20′ E, 39°47′–40°59′ N with a total area of 18,800 km^2 and a population of 105,000 in 2006. Like Linze, Jinta is one of the three most desertified counties in Jiuquan Prefecture and has suffered from desertification for many years. According to the county annals published in 1992, there were about 415 wind gaps and about 10 townships and 46 villages were negatively affected by desertification-related problems (e.g., soil erosion, groundwater depletion, drought, and dust storms). Desertification and dust storms in Jinta have become even worse since the 1990s. This makes Jinta another important source of dust storms in northwest China. Established as one of the central stations under the leadership of Minqin Integrated Desert Control Experimental Station of CAS in 1959, Jinta Desert Control Station was handed over to Jinta Forestry Bureau in May of 1977 and has begun cooperating with GDCRI since 2005. Its administrative activities are supervised by Jinta Forestry Bureau, while its professional work is under the direction of GDCRI (GDCRI 2006).

Guazhou is located at 94°45′–97°00′ E, 39°52′–41°53′ N with a total area of 24,100 km^2 and a population of 119,100 in 2006. Guazhou has suffered from desertification for thousands of years along with its long history of reclamation and immigration. Due to serious influences by sand dunes and desertification, its county seat was moved many times before 1966. Because windy days consist of one third of the year, it is also known as the World Wind Reservoir (*Shijie Fengku*). Guazhou established its own Desert Control Station in the early 1990s under the leadership of Guazhou Forestry Bureau. Although this station has no formal cooperation with GDCRI and CAS, GDCRI did a desert control and forestation experiment in Beiqiaozi Village in Guazhou from 1985 to 1987 and the national Bureau of Three Norths Shelter Forest Construction established a Gansu Observation Station of Dust Storm Weather Trend in Guazhou in 2003.

Dunhuang is located at 92°13′–95°30′ E, 39°53′–41°35′ N with a total area of 26,960 km^2 and a population of about 140 thousands in 2004. Dunhuang has also suffered from desertification for thousands of years. Along with reclamation and immigration since the Yongzheng Period (1723–1735) of Qing Dynasty, especially since the 1980s, desertification problems have become more and more serious and the level of underground water has declined dramatically as in Minqin. Dunhuang does not have an independent and formal desert control station, but its Forestry Technology Center under the leadership of the Forestry Bureau takes charges of desert control in the county and has some formal cooperation with GDCRI and Beijing Forestry University.

Data Collection and Analysis

From 26 June 2006 to 12 February 2008, we carried out a random social survey. The response rate was over 90%, and 1974 valid responses were received (Table 1a). Since many old farmers could not read, the questionnaires were first randomly distributed to the students in different high schools, who were trained to help their family members, neighbors, and relatives. High school students often came from all the townships within the county. If there were more than high schools within the county, we would include all the high schools. Also, the students were trained to help their family members as well as their neighbors and relatives to fill the questionnaires. Thus the possibility that only families with high school students were included was reduced.

In our survey, a six-point scale—very important, important, moderately important, dispensable, negative, and unknown—was used to gauge respondents' evaluation of scholars' participation. Some multiple-choice questions were also included with five possible responses—very serious, serious, moderately serious, not obvious, and greatly ameliorated (as compared to previous conditions in the 1950s) (Yang 2007a; Yang and Wu 2009).

Considering that the writing skills of the respondents were limited, we also conducted face-to-face interviews to complement the survey data. From June 6 to July 31, 2007, we interviewed 78 volunteers (Table 1b). These volunteers included farmers, scholars, government officials, businessmen, and members in religious groups or NGOs who were directly involved in the mitigation programs participated by scholars. Their age ranged from 21 to over 80 years. The interviewees were volunteers from various organizations (such as desert control stations and firms). For those living in rural areas, we went to randomly selected villages to interview farmer volunteers. We have kept the interview results confidential and made sure that the identity of any respondent would not be revealed in any circumstance.

Before and after the surveys and interviews, we also extensively collected archives such as county annals, governmental gazettes from 1949 to 2007, and other materials

Table 1 Survey and interview distribution in the seven counties, China (2006–2008)

	Counties							Total
	Zhongwei	Minqin	Jingtai	Linze	Jinta	Guazhou	Dunhuang	
(a) Survey								
The number of sent copies	300	370	280	250	300	260	450	2210
Response rates	0.95	0.92	0.93	0.96	0.93	0.93	0.92	0.93
The number of valid copies	280	322	236	239	260	237	400	1974
(b) Interview								
Farmers and other citizens	5	6	3	4	4	6	1	29
Scholars	4	11	3	3	2	2	2	27
Government officials	1	11	3	1	0	0	1	17
Businessmen	0	0	0	0	0	0	4	4
Religious groups or NGOs	0	1	0	0	0	0	0	1
Total	10	29	9	8	6	8	8	78

such as research reports, government documents, and historical memoirs from the seven counties for background information, design knowledge, and validity check. The detailed process-tracing and life-story analysis (George and Bennett 2005; Plummer 2001) of these archives allowed us to identify indicators that can best measure the effectiveness of scholars' participation in combating desertification.

Results

Significance of Scholar Participation and Its Relationship with Land Amelioration

More than 45% of the respondents from the seven counties indicated that scholars in combating desertification were "very important" or "important" (Table 2a). When asking for the impact of indigenous scholars, this percentage increased to 60% (Table 2b). For evaluating the impact of scholar organizations, this percentage was larger than 50% (Table 2c). In Dunhuang County, over 80% of the respondents rated scholars' participation as effective in helping combating desertification.

All the six kinds of roles of scholars were found in the seven counties (Table 3). The most important scholars' roles identified were information provider; the second important was entrepreneurial activity organizers (for farmers or herders). In the four counties—Zhongwei, Guazhou, Dunhuang, and Minqin—the role as information providers was the most important, while in the other three counties—Linze, Jingtai, and Jinta—the role as entrepreneurial activity organizers. For all the counties, scholars as

Table 2 Percentages of survey respondents who indicated the importance of scholar participation in China (2006–2008)

Options	Counties						
	Zhongwei (%)	Minqin (%)	Jingtai (%)	Linze (%)	Jinta (%)	Guazhou (%)	Dunhuang (%)
a. Scholars							
Very important	43	23	40	34	29	46	40
Important	26	24	28	44	28	24	39
Total	69	47	68	78	57	70	79
b. Both scholars and "indigenous scholars"							
Very important	38	28	37	33	20	29	39
Important	34	36	36	46	47	31	42
Total	72	64	73	79	67	60	81
c. Scholar organizations							
Very important	48	27	56	33	20	40	51
Important	28	29	21	46	47	27	33
Total	76	57	77	79	67	67	84
d. Average							
Average	72	56	73	79	64	66	81

Table 3 The six roles of scholars as rated by percentages of survey respondents who indicated them in the seven counties, China (2006–2008)

Roles of scholars[a]	Counties						
	Zhongwei (%)	Linze (%)	Jingtai (%)	Guazhou (%)	Jinta (%)	Dunhuang (%)	Minqin (%)
Information providers for governments and farmers	50 [1]	44 [2]	38 [2]	43 [1]	45 [2]	50 [1]	41 [1]
Scholar-entrepreneurs of farmers	47 [2]	54 [1]	43 [1]	38 [2]	47 [1]	41 [2]	51 [2]
Self-interest pursuers	15 [3]	21 [3]	17 [3]	15 [3]	13 [3]	7.0 [3]	24 [3]
Agents of governments	5.4 [4]	5.0 [6]	3.0 [4]	4.0 [4]	4.0 [4]	2.0 [5]	5.0 [5]
Information providers, agents and scholar-entrepreneurs of firms	4.6 [5]	12 [4]	3.0 [5]	3.0 [6]	1.0 [6]	3.0 [4]	4.0 [6]
Information providers, agents, and scholar-entrepreneurs of various religious groups and NGOs	3.0 [6]	8.0 [5]	0.4 [6]	4.0 [5]	1.5 [5]	1.0 [6]	9.0 [4]

[a] The categories of roles of scholars are based on Yang and Wu (2009); [1] to [6] refers to the rank

Table 4 Percentages of survey respondents who indicated what kinds of scholars were the most important scholars participated in combating desertification in China (2006–2008)

Options	Counties						
	Zhongwei (%)	Minqin (%)	Jingtai (%)	Linze (%)	Jinta (%)	Guazhou (%)	Dunhuang (%)
Researchers and technicians in Desert Control Stations	58 [1]	42 [1]	52 [1]	63 [1]	49 [2]	55 [1]	45 [3]
Agricultural technicians	31 [3]	31 [2]	45 [2]	43 [2]	56 [1]	40 [2]	52 [2]
Other kinds of technicians (in fields such as irrigation and environmental pollution)	51 [2]	21 [3]	49 [3]	39 [3]	45 [3]	32 [3]	61 [1]
Various experts, professors, and researchers (EPRs)	28 [4]	19 [4]	17 [4]	15 [4]	10 [4]	15 [4]	38 [4]

[1] to [4] refers to ranks; because the question in the surveys is designed as a multiple-choice question, the total percentages in every county are over 100%

self-interest defenders were rated as the third most important role. The fourth was important role was representative agents of the governments; the fifth, representative agents of firms with stakes; and the sixth, representative agents of NGOs and other groups involved.

Respondents rated researchers and technicians in local desert control stations as the most important participants for combating desertification (Table 4). They rated agricultural technicians the second most important group of scholars. Other kinds of technicians (in fields such as irrigation and environmental pollution) were the third most important group of scholars. Although various experts, professors, and researchers from universities and research institutes (EPRs) are often expected to play an important role in combating desertification, the survey showed that they were the least important. In all the seven counties, they were ranked in the fourth place.

Our survey indicated that the results of desertification combating were quite different among counties (Table 5). Although it was impossible to get accurate data on the size of the desertified areas in the seven counties before scholars' intervention in the 1950 s, archived local records suggested that these counties experienced a similar degree of desertification in the 1950s. After more than 50 years of scholars' participation, we found that the order, from least to highest, of respondents in the these counties that thought desertification had been ameliorated by scholar participation was consistent with the order, from the highest to the least, of the percentage of their desertified area assessed independently by other researchers (e.g., Li and others 2003; Zhongwei was not included in this study) (Table 5). Also, the degrees of land amelioration in these counties as rated by the survey respondents were supported by our analysis with survey and historical data, and consistent with findings by others as well (e.g., Li and others 2004; Yuan and Ma 2006; Zhao 2003).

A chi-square analysis of respondents' perception of the value of scholars' participation in desertification combating show that the chi-square value was 44.67 and its asymptotic significance was less than 0.00. At the 0.05 significance level, we could conclude that perceived scholar participation did influence land amelioration. Analysis of

Table 5 Percentages of survey respondents who indicated the degree of desertification severity and land amelioration and desertified areas in the seven counties, China (2006–2008)

Options	Counties						
	Zhongwei (%)	Minqin (%)	Jingtai (%)	Linze (%)	Jinta (%)	Guazhou (%)	Dunhuang (%)
Very serious	09	82	15	11	15	22	33
Serious	22	16	49	27	45	36	51
Moderately serious	33	1.0	9.0	33	15	11	10
Not obvious	6.0	1.0	4.0	5.0	4.0	2.0	1.0
Greatly ameliorated	29	0.0	13	18	18	30	5.0
Desertified areas (percentages of the total areas)	No data	55.2	21.1	14.5	13.2	93.9	34.5

the interviews and achieve data also show that scholar participation increased the degree of land amelioration. For example, all the interviewees in Jinta agreed that scholars played an important role in combating desertification. Several farmer interviewees highly praised the scholars' functions in desertification control and agricultural planting. One interviewed official in Linze even argued that in a society with five kinds of members working at desertification combating (including farmers, officials, scholars, firms, and various religious groups and NGOs), scholars' functions accounted for at least about 20% of what.

Mechanisms and Factors Related to Scholars' Participation

Thirty of the more than 100 measures used in the surveys and interviews appeared to have significantly influenced the effectiveness of scholars' participation effectiveness. Their high chi-square values (most of them were greater than 30) with asymptotic significances at the 0.05 significance level showed that they were highly correlated with the degree of land amelioration which was our indicator for scholar participation effectiveness (Table 6).

We then used a factor analysis to reduce these 30 measures to 13 factors (Table 7). Among these 13 factors, the first seven are about the characteristics of scholars' individual behaviors, and the other six were germane to the attributes of scholar organizations and their external support (the mechanisms of scholars' participation). Correlation analysis show that all these factors are positively correlated with the success rate of land amelioration efforts; although a few of them were not very significant (one reason might be related to its small sample dataset).

Of the seven factors about scholars' individual behaviors, the first factor (F1, significant participation of local scholars) includes significance of scholar participation, number of scholars participated, types of scholars, time they stayed in the county, and places from where they came. Except for the types of scholars, the chi-square values of these measures were all high (Table 6), and their coefficients with land amelioration were all positive. The more local the scholars were, they more effective they appeared to be in combating desertification. Also, Chi-square values of the four types of scholars showed that researchers and technicians in local desert control stations and other kinds of local technicians (in the fields such as irrigation and environmental pollution) were at least as effective as the local agricultural technicians.

Although Environmental Pollution Researchers (EPRs) were the least involved scholars in the past decades according to the survey, its highest Chi-square value (Table 6) among the four types of scholars suggested that their participation in desertification control was even more impactful than that of the other scholars. A correlation analysis shows that the coefficients of agricultural technicians and EPRs with land amelioration were negative (-0.152 and -0.244). That is, the more these two types of scholars participated, the more serious desertification condition became. Agricultural technicians often focus on economic development of agriculture. This would deteriorate local desertification condition. But why the coefficient of EPRs was also negative? Through analyzing the interview data, we found that although these scholars often did not fully understand local conditions and had no concrete and reasonable ideas on how to resolve local problems, their suggestions were often respected by local officials in their local policy making. Activities and policies based on their suggestions often deteriorated desertification condition rather than improved land amelioration. This phenomenon was pointed out by almost all of the interviewees. For example, in Minqin the interviewees said that the advice of planting white poplar to combat desertification by outside experts during the 1980 s and 1990 s deteriorated rather than improved desertification condition. Also, the current advice of forcing farmers to grow vegetables in plastic greenhouse by some agriculturalists has directly led to much derelict land and the impoverishment of many households.

Two important problems of scholars' social status (F2) were "independence of social identity" and "levels of

Table 6 Chi-square values of the 30 measures and their asymptotic significances

Factors	Chi-square values	Asymptotic significances
(1) Participation frequency (PF) of researchers and technicians in local desert control stations	44.67	0.000
(2) PF of local agricultural technicians	25.05	0.000
(3) PF of other kinds of local technicians	44.67	0.000
(4) PF of various experts, professors, and researchers from universities and professional institutes (EPRs)	78.84	0.000
(5) Participation significance of scholars	44.67	0.000
(6) Number of participated scholars	44.67	0.000
(7) Time scholars stayed in the county	44.67	0.000
(8) Places from where scholars came	44.67	0.000
(9) Independent social identity of scholars	6.88	0.009
(10) Social status of scholars	30.37	0.000
(11) Enthusiasm of scholars	37.79	0.000
(12) Capacity of scholars	44.67	0.000
(13) Leadership of scholars	44.67	0.000
(14) Scholars' knowledge on combating desertification and environmental governance	44.67	0.000
(15) Scholars' knowledge on local conditions	44.67	0.000
(16) Scholars' knowledge on local social relationships and networks	44.67	0.000
(17) Social capital of scholars	55.11	0.000
(18) Social responsibility of scholars	37.79	0.000
(19) scholars action orientation	44.67	0.000
(20) Scholars' respect to ideas of other social actors	44.67	0.000
(21) Federal organizations	44.67	0.000
(22) Concrete organizational purposes	45.65	0.000
(23) Democratic management	46.63	0.000
(24) Collaborative management	44.67	0.000
(25) Mechanisms of awards and sanctions	44.67	0.000
(26) Steady scholar-entrepreneurship	42.32	0.000
(27) Realization of expected benefits	44.67	0.000
(28) Combination between environmental protection and economic development	68.26	0.000
(29) Experiment-extension governance method	44.67	0.000
(30) Steady external support	31.33	0.000

$\alpha = 0.05$

social status". Social identity is an individual-based perception; it describes the individual's self-concept derived from perceived membership of social groups (Hogg and Vaughan 2002). The chi-square value of the independence of scholars' social identity was the smallest among all the 30 measures (Table 6). Also, its negative coefficient with land amelioration (−0.166; but not significant at the 0.05 significance level) showed that although the importance of scholars' independence of social identity was stressed both by our survey respondents and interviewees, it might have both positive and negative influences on land desertification with scholar participation. On the one hand, a certain level of independence was a precondition for scholar participation; on the other hand, too much independence might also harm the scholars' collaboration with other social actors. Thus, the overall chi-square value of scholars' social position was also the smallest among all the 13 factors (Table 7).

Scholars' enthusiasm and capability (F3) also influenced the effectiveness of their participation. The chi-square value of enthusiasm, however, was smaller than the values of the two components of capability of scholar participation—capacity of scholars and leadership of scholars (Table 6). That is, although both enthusiasm and capacity were important for scholars' participation, capacity was often more important than enthusiasm.

Three types of knowledge (F4) influencing scholar participation effectiveness are knowledge on combating

Table 7 Chi-square values of the 13 factors and their asymptotic significances

Factors	Chi-square values	Asymptotic significances
F1. Significance of scholar participation, number of scholars, types of scholars, time they stayed in the county, and places from where they came	44.67	0.000
F2. Social position (independent social identity and social status)	11.54	0.000
F3. Enthusiasm and capability of scholar participation	44.67	0.000
F4. Three kinds of knowledge	44.67	0.000
F5. Social capital	55.11	0.000
F6. Social responsibility and action orientation	44.67	0.000
F7. Respect to ideas of other social actors	44.67	0.000
F8. Federal organizational structure and concrete organizational purposes	23.37	0.000
F9. Democratic and collaborative management and the federal mechanism of awards and sanctions	44.67	0.000
F10. Steady scholar-entrepreneurship	42.32	0.000
F11. Combination between economic development and environmental protection	44.67	0.000
F12. Experiment-extension governance methods	44.67	0.000
F13. Four kinds of steady external supports	31.33	0.000

$\alpha = 0.05$

desertification, on local conditions, and on local social relationships and networks. Their respective and overall chi-square values (Tables 6 and 7) indicate that they were equally important in combating desertification. Furthermore, our study found that the three most important subsets of knowledge on combating desertification are (1) general scientific knowledge of desertification and dust storms, (2) particular knowledge on local desertification and dust storms, and (3) general knowledge of environmental management (Table 8a).

Table 8 Scholars' characteristics and differences in mechanisms of organizing scholars' participation as rated by the percentages of survey respondents in China (2006–2008)

	Counties						
	Zhongwei	Linze	Jingtai	Guazhou	Jinta	Dunhuang	Minqin
a. The three kinds of the most important scientific knowledge							
On desertification and dust storms	0.375	0.352	0.364	0.307	0.400	0.265	0.370
On local desertification and dust storms	0.300	0.372	0.287	0.253	0.246	0.290	0.335
On environmental management	0.168	0.155	0.128	0.150	0.177	0.203	0.245
b. Scholars' social relationships with other social actors							
With governments	0.071[a]	0.155[a]	0.105[a]	0.073[a]	0.131[a]	0.115[a]	0.112[a]
With farmers	0.032	0.050	0.012	0.050	0.004	0.020	0.087
With firms	0.046	0.046	0.016	0.033	0.023	0.030	0.093
With the fifth sector	0.032	0.017	0.016	0.017	0.019	0.008	0.112[a]
c. Four types of organizational structures							
Hierarchical organizations and vertical control	0.293	0.184	0.310[a]	0.260	0.262	0.228	0.347[a]
Fragmented organizations without much communication	0.154	0.155	0.116	0.087	0.127	0.078	0.159
Fragmented organizations with much communication	0.214	0.172	0.120	0.147	0.277	0.258	0.204
Federal organizations	0.361[a]	0.335[a]	0.275	0.307[a]	0.323[a]	0.375[a]	0.290
d. The four kinds of external support							
Financial	0.204[a]	0.201[a]	0.213[a]	0.220[a]	0.219[a]	0.218[a]	0.211[a]
Technical	0.139	0.146	0.163	0.150	0.092	0.133	0.174
Institutional	0.143	0.071	0.089	0.073	0.012	0.043	0.112
Moral	0.082	0.067	0.050	0.057	0.019	0.028	0.040

[a] Means the highest

Whether scholars had good relationships with other social actors (high social capital) (F5) had the highest chi-square value among all the 13 factors. Also, our study found that in all the seven counties scholars always had stronger relationships with government than with the other social actors. Among four of their relationships with governments, farmers, firms, and various religious groups and NGOs, in all the 14 choices used to evaluate scholars' behaviors, the respondents indicated that the relationship with government was the most important one, in all seven counties (Table 8b).

Factor 6 (scholars' social responsibility and action orientation) (Tables 6 and 7) shows that scholars' sense of social responsibility and action orientation are both important for participation effectiveness, although scholars' action orientation is more important than their sense of social responsibility. Furthermore, the interviewees pointed out that scholars now do not have high sense of social responsibility as their predecessors.

Whether scholars respected ideas of other social actors (F7) also influenced the effectiveness of their participation (Table 7). For example, interviews in Minqin reveal that if scholars and officials had respected each other, scholars could play a more important role.

Factor 8 shows that organizational structure and objectives are important organizational concerns. Although their overall chi-square value was lower than their respective chi-square values, it was still relatively high (Tables 6 and 7). Among the four types of organizational structure—hierarchical organizations and vertical control, fragmented organizations without much communication, fragmented organizations with much communication, and federal organizations—evaluated in the survey, except for in Jingtai and Minqin, more than 30% of the respondents indicated that federal organizations were the most important organizations (Table 8c). A federal organization is a federation of a number of small organizations, each of which may use its social incentives to get its members to contribute toward the collective goals of the whole organization while the federal organization provides some service to them (Olson 1971). For concrete organizational objectives, examples include protection of Yellow River and the Lanzhou-Xinjiang railroad in Zhongwei, the protection of the Jingdian Pumping Irrigation Project in Jintain, and the protection of the county seat in Guazhou. However, because the Jingdian Pumping Irrigation Project only covered part of the county, the objective of combating desertification in the whole Jingtai County was not as concrete as in Zhongwei and Guazhou.

Factor 9 is democratic and collaborative management with the federal mechanism of awards and sanctions. The chi-square values of democratic management, collaborative management, and the federal mechanism of awards and sanctions (Table 6) show that these three measures were almost equally important for scholars' participation effectiveness. The interviewees indicated that democratic management was the most important characteristics of combating desertification in Zhongwei, particularly from the 1950s to the 1970s. Collaboration means two or more individuals or organizations working together for a common goal, and it necessitates "pooling of resources of multiple stakeholders to resolve problems" (Plummer and FitzGibbon 2004, p. 64). It was measured by different kinds of inner collaboration within the county and different kinds of external collaboration between organizations or individuals within the county and out of the county. For example, all the interviewees in Zhongwei stressed its inner collaboration among scholars, farmers, and government officials within the county from the 1950 s to the 1970 s. In particular, they indicated that because of firms' participation in combating desertification, the mechanism of awards and sanctions in Zhongwei had been marketized since the 1990s. They also pointed out that external scholars' and different NGOs' participation since 1980s from all over the world had improved its external collaborative management and the effectiveness of scholar participation.

Steady scholar-entrepreneurship (F10) was also an important factor (Table 7). For example, in Linze the tradition that the head of the Desert Control Station could be the vice supervisor of the county increased its entrepreneurial activities through a formal institutional arrangement. However, because most scholars in Minqin only focused on their own research, scholars entrepreneurial activities in combating desertification was weak.

Factor 11 is about the activities of combating desertification and the improvement of farmers' economic benefits. If people focused more on economic development, desertification condition worsens. Through a correlation analysis, we found that the coefficient of realization of expected benefits with land amelioration was negative (-0.100, but not significant at the 0.05 significance level).

Experiment-extension of governance method (F12) in this study means that scholars first do some experiments in a small area, then gradually extend them to larger areas if successful (Tables 6 and 7).

Finally, steady external support (F13) means that the support from out of the county was regular and continuous. We found four important types of external support—financial, technical, institutional, and moral. Among twelve choices in the surveys given to evaluate the methods to improve the effectiveness of scholar participation, more than 20% of the respondents indicated that financial support was the most important one, and more than about 10% indicated that technical support was the most important one (Table 8d).

Through correlation analysis, we also found that different types of scholars had different sensitivities to the

above discussed factors. The time scholars stayed in the counties, scientific knowledge, scholars' social status, social capital, action orientation, and respect for ideas of other social actors, federal organizational structure, democratic management, and realization of expected interests are all important variables affecting scholar's participation effectiveness, more so for EPRs and technicians than other types of scholars (Table 9a).

For the factors that have positive coefficients (Table 9a), the higher the loadings were, the higher the degree of land amelioration was. The negative correlation coefficients mean that while these scholars had scientific knowledge on desertification control, their knowledge was not the right kind and is not useful for local desertification control. When applied in practice, it reduced rather than enhanced desertification control.

Researchers and technicians in desert control stations were more sensitive than the other scholars to concrete organizational objectives, stable entrepreneurship, environmental protection and economic development, and experiment-extension of governance methods (Table 9b). The higher the factor loadings were, the higher the degree of land amelioration was. Also, local conditions, places from where scholars came, and collaborative managements affected agricultural scholars effectiveness more than the other scholars (Table 9b).

Discussion and Conclusions

Scholar's participation in combating desertification programs in China has been practiced since 1949. But its significance and mechanisms have received little attention from researchers. Our study reveals that scholars played an important and positive role in combating desertification, providing further empirical support for an alternative model for collective action—scholar-participated governance (Yang 2007a, 2009; Yang and Wu 2009). This model is different from the three classical and popular models of central authority (Hardin 1978; Olson 1971), privatization (Buchanan 1965; Coase 1960, 1974; Demsetz 1970; Gordon 1954; Smith 1981), and self-governance (Lichbach 1996; Ostrom 1990, 2000). Scholars who have comparative advantages in knowledge and information over other social actors can help resolve collective action dilemma in social-ecological systems under certain conditions.

Our study also provides empirical support for the six roles of scholars in resolving collective action dilemmas (Yang and Wu 2009). We have identified 13 factors that determine scholar's participation effectiveness in combating desertification. Although not necessarily inclusive, they provide critically important information needed for promoting scholar's participation and rebuilding organizational mechanisms for desertification control. Some of the 13 factors were found important for participatory management in previous research (e.g., Campbell 1992; Fan and Zhou 2001; Fullen and Mitchell 1994; Thomas 1997; Tschakert 2007; Zha and Gao 1997). For example, Varjopuro and others (2008) stressed the multiple and complex needs in participatory management and the collaboration among stakeholders, technical experts, politicians, and other professional stakeholders in fisheries management. Pretty and Ward (2001) called for more attention to the influence of social capital on environmental outcomes. Sitaraman (2006) studied China's cooperation with international organizations in environmental managements.

We have identified several new factors that are important to scholars' participation in helping resolve collective action dilemma, including the local residence time of scholars, the places where scholars are from, the social status of scholars, social responsibility, enthusiasm and capability, action orientation, respect to ideas of other social actors, steady scholar-entrepreneurship, and the experiment-extension governance method. All these factors are also important to participatory management, which have not been adequately examined in the current literature.

Some of our findings are different from previous research. For example, although many studies (e.g., SACDS 1977; Seely 1998; Thomas 1997) stressed the important role of scientists in combating desertification, our study indicated that EPRs and agricultural technicians had little impact on land amelioration, and local scholars were often more important than non-local scholars in combating desertification. Thus, being local and knowing local conditions are crucial. Thus, the Chinese government and policy makers need to rely more on local scholars for local solutions for combating-desertification. Furthermore, although the independence of scholars was emphasized by a number of previous studies (e.g., Mills 1959; Posner 2001; Weber 1978), our study suggested that this "independence" may lead to the lack of interactions with the local stakeholders (including decision makers) which undermines the effectiveness of scholar's participation. Different from previous research which often focused on social relationships between scholars and local farmers (e.g., Fullen and Mitchell 1994; Thomas 1997; Tschakert 2007), our study indicated that the relationship of the participating scholars with governments was often more important than that with farmers, firms, religious groups, or NGOs in China.

Our study also indicated that the relative importance of the 13 factors to the effectiveness to scholars' participation in environmental protection may vary with different types of scholars. For example, EPRs and other kinds of technicians should pay more attention to improve their time staying in the counties, their social status, social capital,

Table 9 Correlation coefficients of different types of scholars and selected variables among the 13 factors

a. EPRs and other kinds of technicians

Types of scholars	Selected variables								
	Time scholars stayed in the counties	Scientific knowledge	Scholars' social status	Social capital	Action orientation	Respect to ideas of other social actors	Federal organizational structure	Democratic management	Realization of expected interests
EPRs	0.776(0.000)	−.736(0.00)	0.793(0.000)	0.652(0.000)	0.854(0.000)	0.735(0.000)	0.566(0.000)	0.852 (0.000)	0.827(0.000)
Other kinds of technicians	0.496(0.000)	−0.693(0.000)	0.417(0.000)	0.529(0.000)	0.487(0.000)	0.467(0.000)	0.525(0.000)	0.347(0.000)	0.669 (0.000)

b. Researchers and technicians in desert control stations and agricultural scholars

Types of scholars	Selected variables						
	Concrete organizational purposes	Stable entrepreneurship	Combination of environmental protection and economic development	Experiment-extension governance methods	Knowledge on local conditions	Places from where scholars came	Collaborative managements
Researchers and technicians in desert control stations	0.513(0.000)	0.723(0.000)	0.593(0.000)	0.471(0.000)	–	–	–
Agricultural scholars	–	–	–	–	−0.921(0.000)	0.561(0.000)	−793(0.000)

The *numbers in the brackets* are their 2-tailed significances at the 0.05 significance level

action orientation, and respect for ideas of other social actors. Both federal organizations and democratic management are important to them. They should strive to help local people realize their expectations. Because their suggestions are valued heavily, these scholars should be cautious when giving advice to local policy makers. Researchers and technicians in local desert control stations, however, should pay more attention to concrete organizational purposes, stable entrepreneurship, experiment-extension governance methods, and the combination between environmental protection and economic development. Also, when agricultural scholars are concerned with agricultural economics, they should pay more attention to local conditions, desertification control, and collaboration with other types of scholars and other organizations.

As the first major step in studying scholars' participation in combating-desertification programs in China, our study is limited in scope, and the findings need to be further tested with more comprehensive datasets from other places around the world. Towards this end, we are currently collecting a large set of empirical cases to test the replicability of these findings.

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