

Science-Driven Governance as an Alternative Solution to the Problems of Collective Action: An Overview of Empirical Studies on Desertification Control in Northern China over the Past Ten Years (2004-2013)

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Abstract: Previous studies have developed three classical models for resolving collective action dilemmas: central authority, privatization, and self-governance. Based on reviewing a series of studies on desertification control in northern China, this article proposes a science-driven governance model as an alternative solution to the problems of collective action and addressed the roles of science, scholars (including scientists, experts, and researchers), and scientific research organizations in desertification control and institutional change as well as their mechanisms. The study provides theoretical and empirical foundations for further research concerning desertification control, collective action, and social governance.

Key words: Combating desertification, scientists, experts, knowledge, research organizations, institutions, institutional change.

Over forty years have passed since Garrett Hardin's challenging article "The Tragedy of the Commons" (1968) and Mancur Olson's influential book "The Logic of Collective Action" (1971). Various models such as central authority (Hardin, 1978; Hobbes, 1991; Pigou, 1932; Olson, 1971; Samuelson, 1954, 1955), privatization (Buchanan, 1965; Coase, 1960; 1974; Demsetz, 1970; Gordon, 1954; Savas, 2000; Smith, 1981), and self-governance (Lichbach, 1996; Ostrom, 1990; 2000) have been applied to resolve social dilemmas in social-ecological systems (Lüshi Chunjiu, 2000; Shijing, 2003; Yang, 2007a; 2007b; 2009; 2010). Each model has its advantages, disadvantages, and applicable conditions (Yang, 2007a; 2007b; 2009; Yang and Wu, 2009). Although Hardin (1968) began his arguments from "No technical solution problems," in practice, we do find that scientists, experts, and scholars, as well as science and knowledge, play an important role in resolving the dilemma of collective action to some extent (Yang, 2007a; 2007b; 2009; 2010; 2012a; 2012b; Yang and Lan, 2011; Yang and Wu, 2009; 2010; 2012; Yang *et al.*, 2010; 2013; Yang and Yang, 2011). My two intuitive problems were: What have science and scientists done, and how can science and scientists do better? During the past ten years (2004-2013), based on a series of empirical studies on desertification control (one of the greatest environmental challenges of our times) (Yang and Wu, 2010)

in northern China (one of the countries most severely affected by large-scale desertification) (Wu and Ci, 2002), my colleagues and I studied the following research problems: a) the role of science in resolving the dilemmas of collective action and its mechanisms; b) the role of scholars (including scientists, experts, and researchers) as science possessors and its mechanisms; c) the role of scientific research organizations and its mechanisms; d) the influence of scientific application on institutional change and its mechanisms; e) the role science and scholars play in social organizations and governance and its mechanisms; f) the interactions among scientists, social scientists, local people, and other social actors; g) the interactions among science, social science, local knowledge, experience knowledge, and common sense, among others. This study tries to provide a short review of our empirical studies and results over the past about ten years (2004-2013).

Methods for Studying the Role of Science and Scientists

Our study was based on a combination of a series of theoretical analyses (especially game theoretical analysis) and empirical studies (mainly field and case studies). In general, we used theoretical analyses to develop our hypotheses and theoretical models and then relied on empirical studies to test the theoretical hypotheses and models (Yang, 2009).

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The four major types of data of the field studies on desertification control in northern China were surveys, face-to-face interviews, observations, and archives. The first 3-year field study was conducted from June 26, 2006, to June 19, 2009, in the Gansu, Ningxia, Inner Mongolia, Shaanxi, and Xinjiang provinces in northern China. We first conducted surveys, interviews, and participatory observations in seven counties, and then we performed participatory and non-participatory observations and random interviews in another 14 field cases. In this field study, we received 1,974 valid responses in total with a greater than 90% response rate, and we interviewed 78 people (Yang, 2009, 2010, 2012a; Yang *et al.*, 2010; Yang and Wu, 2010) (Figures 1 to 6 and Table 1). The second 1-year field study was conducted from March to December 2011. In this study, we received 4,406 valid survey responses, interviewed 118 people, and recorded 52 observations (Yang *et al.*, 2013) (Figures 7 to 9 and Table 1). In both field studies, the survey respondents and interviewees included farmers, herders, officials, experts, professors, businessmen and others. Various archives, including government gazettes, government documents, county annals, research reports, and published and unpublished literature, were collected.

From December 2004 to February 2013, we studied 48 Chinese cases on desertification control (Table 1). The data of these cases were mainly based on various published and unpublished literature, such as county annals, government documents, Statistical yearbooks, journal articles, books, research reports, official web materials and historical memoirs. To test the generalizability of the findings from the field studies by changing the coverage, spatial and temporal extent, cultural contexts, and fields, 18 non-Chinese cases on desertification control and other governance dilemmas from other 13 countries including Australia, Israel, Pakistan, Spain, Turkmenistan, United States, Chile, India, Iran, Iraq, Niger, Tunisia, Uzbekistan in six continents including Africa, Asia, Australia, Europe, North America, and South America and 17 Chinese cases on other dilemmas (such as village governance, rural education, rural economic development, economic movement, political movement, and irrigation) were also studied (Yang, 2009, 2010; Yang and Wu, 2010).

The Roles and Mechanisms of Scientific Application

Our study found that science played an important role in desertification control in China. The most needed knowledge in desertification control was science and technology on desertification and dust storms, knowledge of local desertification and dust storms, and knowledge related to environmental management and others (Yang and Yang, 2011). The knowledge that has the greatest influence on the results of desertification control was knowledge of forestry, hydraulic engineering knowledge, and general knowledge of environmental governance. The three major methods of science application in China were government dominant, scholar-driven, and multi-actor participation. Furthermore, we found that the extent and effect of the adoption and implementation of science were different, and there was a cubic relationship between the extent and effect of scientific application (Yang, 2012c).

From a social actor perspective, our study also developed a scholar-participated governance model as an alternative to the classical models of collective action: central authority, privatization, and self-governance. The study found that scholars (including various experts, professors, researchers, and technicians) did play an indispensable role in Chinese desertification control and could help other social actors (such as farmers, herders, and government) resolve their collective action dilemma. Scholars could either be information providers (or brokers), entrepreneurial activity organizers and representatives of other social actors or pursuers of self-interest (Yang, 2009; 2010; Yang and Wu, 2009). The four major types of scholars in desertification control were people in various local desertification control stations; agricultural technicians; other technicians; and external experts, professors and researchers (Yang and Yang, 2011). Furthermore, the study found that successful scholar-participated governance shared seven working rules (or design principles) (Table 2a; Yang, 2009; 2010; Yang and Wu, 2010).

The study also found that grass-roots scientific research organizations played an important role in Chinese desertification control. Although their functions were diverse, these organizations mainly focused on policy recommendations



Fig. 1. Interviewing farmers in Xihu Twonship, Guazhou County, Gansu (July 29, 2007).



Fig. 2. The Main Irrigation Canal of Danghe River, Dunhuang County, Gansu (July 31, 2007).



Fig. 3. Yuanyang Reservoir in Jinta County, Gansu (July 28, 2007).



Fig. 4. Psammophyte Garden in Minqin County, Gansu (June 28, 2007).



Fig. 5. Interviewing Researchers in the Desertification Control Station in Jingtai County, Gansu (July 24, 2007).



Fig. 6. Shapotou Desert Research Experimental Station, Chinese Academy of Forestry Sciences in Zhongwei City, Ningxia (July 20, 2007).

and research activities. However, the functions and development of these organizations were restricted because of limited financial support,

organizational structure problems (the vertical control relationship was obvious) and other



Fig. 7. Interviewing businessmen in Naiman Banner (County) and Observations, Inner Mongolia (July 27, 2011).



Fig. 9. The Sino-German Financial Cooperation Project of Comprehensive Desertification Control in Shaquanwan, Yanchi County, Ningxia (August 8, 2011).

issues. Furthermore, the study found an inverted “U” relationship between the local people’s information on grass-roots organizations and their evaluation of these organizations (Yang, 2012b).

The study found that the application of science influenced several aspects of institutional change of Chinese desertification control: Major actors in desertification control, desertification control methods, types of property rights, and laws and regulations. The major sciences influencing institutional change were agricultural science and technology, land development and construction planning, agricultural pest control, knowledge of forestry, knowledge of combating desertification and dust storms, and general knowledge of climate. The study also found that governmental



Fig. 8. Interviewing officials in Dengkou County, Inner Mongolia (August 3, 2011).

behaviors and governmental attitudes toward the application of science, understanding of local knowledge, local conditions, local people, and effectiveness in science and technology transformation and extension were the most important factors influencing the application effects of science on institutional change in desertification control (Yang *et al.*, 2013).

Furthermore, the study found that, different from voluntary, knowledge-driven institutional change based on indigenous knowledge and experiences of local populations (which was discouraged), imposed knowledge-driven institutional change was often perceived as a more progressive, scientific, and rational type of institutional change by government officials and scholars. The study also demonstrated that imposed knowledge-driven institutional change tended to be more successful when eight working rules (Table 2b) were thoroughly implemented (Yang and Wu, 2012), while science-driven institutional change tended to be more effective when nine rules (Table 2c) were aided by (Yang and Li, 2012). Here science mainly referred to natural sciences, while knowledge included not only natural sciences, but also social sciences and local knowledge (Yang and Wu, 2012).

Our study went further to explore the roles science and scholars play in social organizations and governance based on Hayek’s influential research on the use of knowledge in society (Hayek, 1945). Different from Lindblom’s (1977) two highly sophisticated models of humanitarian societies—an intellectually guided society (Model 1) and a preference- or volition-guided society

Table 1. Studied sites and cases from 2004-2013

Studies	Cases	Spatial extents
The 21 cases in field study I (2006)	Zhongwei, Jingtai, Minqin, Linze, Jinta, Guazhou, Dunhuang	County
	Wuwei	Prefecture
	Qingtuahuqu, Hongshaliang Township, Hongyahsan Reservoir Region	Township
	Huazhai Village, Sanjiaocheng Relics, Xingou Village, Shanggou Village, Pig-farm Tree Nursery, Gaolaiwang Village, Minqin Taoists' Forest Ecological Base, Songhe Village, Minqin Desert Control Station and its Psammophyte Garden, Fengjiatang Forest Center	Village
The 12 cases in field study II (2011)	Linze, Minqin, Zhongwei, Yanchi, Dengkou, Ejina, Xinbaerhuzuo, Xilingol, Naiman, Duolun, Wengniute, Aohan	County
The 48 Chinese case studies on desertification control (2004-2013)	Chifeng, Xilinguole, Alxa (Alashan), Yulin, Wuwei, Zhangye, Shihezi, Haixizhou, Jiuquan, Lingwu, Ordos	Prefecture
	Ewenke, Keerqinzuoyihou, Zhalute, Naiman, Aohan, Wengniute, Duolun, Ejina, Wushen, Dengkou, Alashanzuo, Alashanyou, Ejina, Jingbian, Dingbian, Wuqi, Yanchi, Tongxin, Lingwu, Hotan (Hetian), Dalad (Dalate), Tailai, Dorbod (Duerbote), Cele, Qiemo, Qitai, Tianjun, Guinan, Hanyan, Sunan, Maqu, Pingluo, Siziwang, Wuchuan, Xinghe	County
	Wushen Sumu (Uxin Ju)	Township
	Songhe village	Village
The 17 Chinese case studies on other dilemmas (2004-2013)	The Village Governance System in ancient China (Pre-1905), the Household Contract Responsibility System (1978-2008), the Farmers' Movement and Association (1921-1949), the Farmers' Association and Land reform (1950-1953), the Rural Autonomy Movement (1905-1911), the Movement of Local Autonomy (1911-1949), the Cooperative Movement (1949-1956), the Intellectuals' Ideological Remolding Movement (1951-1952), the Anti-Rightist Movement (1957-1958), the Great Leap Forward Movement (1958-1960), the People's Commune Movement (1958-1983), the Four Cleanup Movement (1963-1966), the Great Culture Revolution (1966-1976), the Rustication Movement of Educated Youth (1955-1978)	National
	Yan's Rural Reconstruction Experiment in Ding County (1929-1937), Liang's Rural Reconstruction Experiment, Zouping County (1931-1937)	County
	Tao's Xiaozhuang Normal School Experiment, Nanjing (1927-1930)	Village
The 18 non-Chinese case studies (2004-20013)	The New Village Movement, South Korea (1972-1980s); Integrated Desert Development and Desertification Control, Turkmenistan (1924-2007)	National
	The Landcare Program, Australia (1989-2007); the Negev Case, Israel (1948-2007); People's Planning in Kerala, India (1970s-2007); the "LUCDEME" Project, Spain (1981-2007); the Dust Bowl Case, USA (1932-2007); the Gascoyne Basin, Australia (1876-1980); the Region of Coquimbo, Chile (1900-1980); the Turan Program, Iran (1975-1984); the Greater Mussayeb Project, Iraq (1953-1980); the Golodnaya Steppe, Uzbekistan (1869-1980)	Provincial
	The Mona Reclamation Experimental Project, Pakistan (1965-2007); the Gal Oya Irrigation Project, Sri Lanka (1950-2007); the Luni Development Block, India (1900-1982); the Eghazer and Azawak Region, Niger (1900-1970s); the Oglat Merteba Region, Tunisia (1900-1980s)	Prefecture
	The Vale Rangeland Rehabilitation Program, USA (1962-2007)	County

Table 2. Working roles or fundamental elements for scholar participated governance, imposed knowledge-driven institutional change, science-driven institutional change, and a knowledge-driven society

a. Seven working rules for successful scholar participated governance	a) Sustained participation of field-based scholars. b) Federal organizational structure and concrete and stratified purposes. c) Democratic and collaborative management with the federal mechanism of appropriate awards and sanctions d) Steady local scholar-entrepreneurship e) Realization of expected benefits f) The Experiment-Extension method (social actors first do experiments in relatively small experimental areas or zones, and then extend them gradually to broader areas after obtaining adequate experience) g) Reliable external support
b. Eight working rules for successful imposed knowledge-driven institutional change	a) The perception of potential gains from institutional change b) The continuing appeal and devoted support of knowledge-based entrepreneurs c) Coordination of various goals of institutional change d) Participation of multiple organizations and democratic and collaborative management e) The realization and fair distribution of benefits and feasible conflict-resolution mechanisms f) Incremental institutional change with the experiment-extension method g) Resistance of external institutional intervention and reliable external institutional support h) Building an efficient, harmonious nested framework among the myriad institutions
c. Nine working principles for effective science-driven institutional change in desertification control	a) Biological controls provide major technical support for combating desertification b) Agricultural controls provide technical supplements to biological and other technologies c) There is effective synergy among different types of scientific methods for desertification control d) Government is a primary participant that guides programs for combating desertification but does not suppress the participation of other social actors and organizations e) Other social actors and organizations, such as farmers (or herders), families, communities, and scholars, participate in desertification control and play an effective role f) There are coordination, communication, and conflict-resolution mechanisms among the various social actors g) There are localized, collaborative, and nested laws and regulations regarding desertification control h) There are localized, collaborative, and nested operation mechanisms for laws and regulations regarding desertification control i) There are localized, collaborative, and nested rules and methods for desertification control
d. Five fundamental elements for a knowledge-driven society	a) There is dispersed and specialized knowledge production b) There is dispersed and asymmetric knowledge possession c) knowledge-driven volitions and consensus are criteria for knowledge d) The satisfaction of diverse and heterogeneous individual needs is realized through knowledge-driven institutional arrangements e) There are multiple methods of knowledge application.

Sources: Yang, 2009; 2010; 2012; Yang and Li, 2012; Yang and Wu, 2010; 2012.

(Model 2), we developed a knowledge-driven society as an alternative model. Furthermore, we studied the five fundamental elements of a knowledge-driven society (Table 2d) (Yang, 2009, 2010, 2012a).

Science-Driven Governance and Current Studies

In summary, during the past ten years, especially the past eight years, my colleagues and I proposed a science-driven governance model as an alternative solution to the classical models of collective action, and we studied the roles and mechanisms of science, scientists, and scientific research organizations in desertification control, instructional change, and social organization and governance. These studies not only supply a new theoretical tool for us to understand the problems of collective action, but they also provide concrete instructions to promote the functions and roles of science, scientists, and scientific research organizations in desertification control and other types of environmental and social governance.

Our current studies focus on the interactions among science, the social sciences, and local knowledge as well as among scientists, social scientists and the local people in desertification control and other forms of environmental governance. Furthermore, we are interested in the roles of scholars, science, and knowledge in community environmental conflict resolution.

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