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Roles of science in institutional changes: The case of desertification control in China

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ABSTRACT

Although the importance of science, in both desertification control and other types of environmental governance, has been emphasized by many studies, little is known about how science influences institutional changes. Based on a method combining surveys, interviews, observation, and a meta-analysis of the literature, this study explored the roles of science in institutional changes associated with desertification control in northern China. There are five major results of this study: (1) the application of science significantly improved the outcome of desertification control by influencing several aspects of institutional changes; (2) the major aspects of the institutional changes were identified (major actors in desertification control, desertification control methods, types of property rights, and laws and regulations); (3) the effects of applied scientific desertification control measures (SDCM) had more impacts on institutional changes than the extents of adoption and implementation of the measures; (4) six scientific areas had the greatest effects on institutional changes of desertification control were observed (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); and (5) the most important factors influencing the application effects of science on institutional change in desertification control were governmental behaviors, governmental attitudes toward the application of science, understanding of local knowledge, local conditions, local people, and effectiveness in science and technology transformation and extension. These findings shed new light on the influence of scientific measures on institutional changes by addressing large-scale, chronic environmental problems, such as desertification control in China and in other arid lands around the world.

1. Introduction

Numerous studies have shown that science (primarily natural science and technology) may play an important role in desertification control (Bauer and Stringer, 2009; Reynolds et al., 2007; Thomas, 1997; Winslow et al., 2011; Xia and Fan, 2000; Yang, 2009, 2010; Yang et al., 2010; Yang and Wu, 2009, 2010). Marx and Engels (1968) argued that technology plays a definite role on the institutional structure of a society. Lin (1989) also indicated that technological advancement is one of four important sources of institutional disequilibrium. Changes in technology not only shape institutional structure but also affect the efficiency of particular institutional

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arrangements. For example, Anderson and Hill (1975) pointed out that the privatization and leasing of public grazing land in the American West was induced by the innovation of low-cost and barbwire fencing. Day (1967) and Binswanger (1978) reported that tractors and other farm machinery reduced supervision cost, and resulted in a shift from sharecropping to owner operations (or from sharecroppers to wage workers).

On the one hand, institutional arrangements may hinder or promote the adoption and implementation of science-based measures in environmental governance (McNie, 2007; Lidskog and Sundqvist, 2002; Garcia and Charles, 2008; Bauer and Stringer, 2009; Yang and Wu, 2010; Akhtar-Schuster et al., 2011). On the other hand, scientific knowledge can significantly influence the process of institutional change (Miller et al., 2010; North, 1990; Ruttan, 1978, 1984; Ruttan and Hayami, 1984). However, the interactions between science and institutional dynamics are yet to be fully understood. This is especially true as to how science influences the institutional changes in desertification control because little has been done on this topic.

Our previous research (Yang and Wu, 2012) suggests that knowledge-driven institutional change may have played a significant role in combating the desertification in northern China during the last six decades; however, because of the lack of data at that time, we were not able to address the question of how science actually influenced these institutional changes. Thus, the main objective of this study was to analyze the roles that science, when applied to desertification control, played in institutional changes. Specifically, we attempted to address the following two research questions:

(1) Does science significantly influence institutional changes during combating desertification, and in what respects?
(2) What are the key factors impeding or promoting the roles of science, and how can these roles be improved?

Based on the assumption that both scientific application and institutional change are heterogeneous, the hypotheses of this study are: (1) the extent of adoption and implementation of scientific measures (i.e., how much science has been applied in desertification control) and its effect (i.e., the effectiveness of the scientific application) influence the effectiveness of institutional changes in desertification control; (2) the key factors impeding or promoting the roles of science have different effects on the effectiveness of institutional changes in desertification control. To answer these questions and to test the hypothesis, we conducted a series of analyses based on field studies in China, which for decades has been one of the countries most severely affected by large-scale desertification (Wu and Ci, 2002).

2. Study area and research methods

2.1. Study region

We chose 12 counties in three adjacent provinces in northern China for the field studies. Among these counties, there are two in Gansu, two in Ningxia, and eight in Inner Mongolia (Fig. 1). These counties are located at 99°51′E–121°35′E, 36°59′N–49°46′N with four in the arid zones, two in the transitional zones between the arid and semi-arid regions, two in the semi-arid zones, and three in the transitional zones between the semi-arid and semi-humid regions. These counties have population densities of 2–69 per km^2, an annual average temperature ranging from −0.5 to 9.5 °C, an annual average precipitation of 115–460 mm, an annual average evaporation of 1714–2644 mm, and an annual wind speed of 2.3–4.2 m per second (Table 1). Land conversion, groundwater pumping for agriculture, and wind (as the major physical erosive force) are often considered to be major causes of desertification in these areas (CCICCD, 2000, 2002). Furthermore, the Chinese Academy of Sciences (CAS) has operated laboratories and field stations in all of these counties for many years; some of these laboratories and field stations were founded as far back as the 1950s.

2.2. Data acquisition

This study is based on a combination of four types of data: surveys, interviews, observations, and archives. The random surveys were conducted from March to December in 2011, with 4194 valid responses overall (Table 2a and b). Considering that many of the old farmers could not read, we first randomly distributed the questionnaires to high school students, who often came from all of the townships within the county and were trained to help their family members, neighbors, and relatives in answering the questions. If there was more than one high school within the county, we included all of the high schools or chose the school with students that represented the population of most of the townships within the county. Because multiple social actors and organizations participated in desertification control projects in China (Yang, 2009, 2010; Yang et al., 2010; Yang and Wu, 2010), the survey respondents included farmers, as well as middle school teachers and students, desert control station staff, government officials, and businessmen (Table 2b). This method has been practiced for many years and in multiple studies (Yang, 2009, 2010, 2012; Yang et al., 2010; Yang and Wu, 2010) and has proven to be a valid and efficient method for collecting data in rural China.

Face-to-face interviews were conducted from June 2006 to February in 2008 in Minqin, Linze, and Zhongwei and from July to August in 2011 in the other counties, with 118 interviewees from approximately 20 to more than 60 years old to complement the survey data (Table 2c). The interviewees included both volunteers (e.g., farmers or general citizens) and people recommended by the offices of the county bureaus, research institutes (e.g., desert control stations), and businesses. The interview questions were similar to the survey questions, but they were open-ended. We ensured that the identity of any respondent would not be revealed in any circumstance by keeping the interview results confidential.

The participatory and non-participatory observations were conducted during the same period of the interviews, and they were mainly used to acquire some intuitive and direct understandings of the activities and functions of the desert control stations, scientific applications in desertification control, types of property right arrangements, and desert control results; some issues were also raised by the interviewees. Furthermore, in each county, we visited the Bureau of Forestry, the Bureau of Environmental Protection, the desert