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Agricultural causes of desertification risk in Minqin, China

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Abstract

This study uses statistical modeling techniques to develop a desertification risk index (RI) for Minqin County, Gansu Province, China. Twenty socio-economic factors were selected and compared with the RI results to explore the spatial and temporal variability of desertification risk in the study area and to identify possible local driving forces behind desertification risk. The explanatory factors were different in 1988, 1992 and 1997, possibly reflecting the role of temporal variation as a contributor to desertification. The average number of sheep per-household was found to be an important indicator of change in desertification risk, while changes in ridge crop planting area explained the distribution of the rate of change in desertification risk in 1988–1992. The results suggests that the RI was useful in expanding the understanding of spatial temporal desertification issues in Minqin County, as well as identifying a current set of agricultural activities related to desertification risk. Further, given the limited nature of consistent data and observations for the area, development of the RI also served to establish a baseline for future investigations into desertification change and the risks such change might pose for the region.

Keywords: Desertification risk index; Multiple regression; Cluster analysis; Agricultural activity; China

1. Introduction

Population growth and economic development continue to place increasing pressure on land use, particularly in developing areas of the world. Unfortunately, the areas most often in need of economic development are areas where the environment is fragile. In China, and particularly in west China, the over and inadequate use of land has contributed to a number of serious environmental problems, especially desertification—defined as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (INCD, 1994). While there is support for each of the two causes as important relative to causing desertification, no consensus has been reached regarding the exact role the two factors play (Mainguet and Da Silva, 1998). Mcclure (1998) pointed out that desertification in the United States was due to a variety of factors including improper agricultural practices, livestock overgrazing, mining, fire management schemes, recreation practices, deforestation, urbanization, and the introduction of exotic species. Girma (2001) found that the major causes of land degradation in Ethiopia related to rapid population increases, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production. As such, inappropriate land-use systems and land-tenure policies enhance desertification. In other research, human population pressure has been shown to be the leading cause of desertification (Darkoh, 1998; Ayoub, 1998; Liu and Ci, 2000). Ambiguities, however, surround the impact population growth and density have on desertification—recent examples in Africa of 'more people, less erosion' have been reported (Tiffen et al., 1994; Darkoh, 1994).

In China, there has been an attempt to reconcile the conflict of opinions by taking into account the different temporal and spatial scales of desertification, as well as its possible initiation and development characteristics. Natural variables played a major role in historic desertification analysis in China, while anthropogenic elements, such as improper land management practices taking precedence over ecological principles, have been blamed for more contemporary desertification issues (Dong and Liu, 1993; Zha and Gao, 1997). Although they have been studied extensively, the causes or driving force factors leading to desertification are still not fully understood. There is also a lack of reliable data on desertification making the development of a baseline against which to measure change difficult (Cardy, 1994). This is particularly true in China were spatial boundaries are often subject to change or redefinition. Another aspect of the problem relates to scale. The complex of socio-economic and biophysical factors involved in land

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degradation operates at different scales and at different times throughout the world (Lambin, 1993; Reynolds, 2001). As such, a multi-scale approach is necessary to better understand the structure and function of scale dependencies as they relate to desertification risk.

Only recently have efforts been underway to better quantify the spatial temporal relationship between desertification and its causes (Prince, 2002). While different modeling approaches have been adopted in the study of land use and land cover change, they have only recently been applied in desertification studies (Verburg et al., 1999; Serneels and Lambin, 2001). Modeling can be an important technique in analyzing and describing processes of desertification change in addition to furthering our understanding of the relationship between the socio-economic and ecological factors involved and their affects on desertification.

China, as one of the more severely desertified countries, has about 14% of its population fostered in oases environments (Yang and Wang, 2001). With increasing pressure on land use, especially since the 1980s, increasing desertification has become a serious issue in the arid regions of China where oasis environments provide the basis for life and economic development. At the state level, a campaign to control land desertification in has been active since the 1990s. The choice of solutions for the problems affecting oases, particularly from a human impact perspective, often depends on location specific causes of desertification rather than on those globally induced. Certainly the combination of the two forces in sensitive areas subject to development pressure greatly exacerbates the need for monitoring and analysis. Unfortunately, there are only a few studies on desertification in China that provide an integrated assessment of the driving forces and their consequences at the local level, let alone that include spatial temporal components.

The Minqin oasis (Minqin County, Gansu Province, China), as a representative Chinese oasis sustained by limited water resources from an inland river in the arid zone, has become seriously degraded in recent years due to regional economic growth initiatives and continued population pressure (Gu, 2002). While Sun and Li (2002) were able to produce a land desertification grade map for 1988, 1992 and 1997 based on a remote sensing classification of land surface spectral information, albedo and NDVI images, related research on desertification risk remains scarce.

The objectives of this paper were to: (1) develop a statistical index of desertification risk for Minqin County, Gansu Province, China, and (2) identify any potential causal factors associated with temporal changes in desertification risk, particularly those agricultural activities that may be contributing to changes in desertification risk for given areas. It is hoped that through a better understanding of desertification risk at the community level, a better set of corrective actions and policies can be put in place.

2. Materials and methods

2.1. Study area

The study area is located in Gansu Province in northwest China (ranging from 101°49′ to 104°12′E and from 38°03′ to 39°28′N) with an estimated area of 15,870 km^2 (Fig. 1). The Minqin oasis lies in a basin along the lower reaches of the Shiyang River. Elevations in the region range from 1295 to 1460 m, sloping generally downwards from the southwest to the northeast. The oasis is surrounded by the Baidan Jilin Desert in the west and north and Tengger Desert in the east. The Wuwei oasis lies to the south.

The area has an arid continental climate with an average annual temperature of 7.8 °C (average maximum 23.2 °C in July and average minimum −9.6 °C in January). The annual average temperature difference is 32.8 °C, with a daily average temperature difference of 15.2 °C. The accumulated active temperature ≥0 °C is 3655 °C and ≥10 °C is about 3114 °C. The annual daily mean sun duration is 3028 h, with a global radiation of 137.22 kcal/cm^2. Mean annual precipitation in the

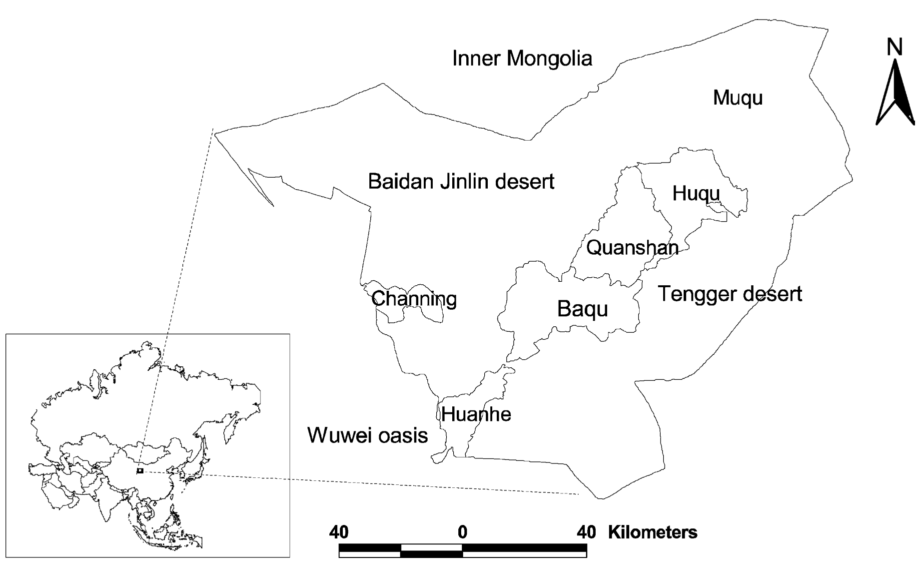

Fig. 1. Location of study area.