Analysis of Driving Forces of Land Desertification in Duolun County, Inner Mongolia Based on Logistic Regression Model (Postprint)

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Date: 2019-01-11T00:00:00+00:00

Abstract

Using vector data of land desertification for Duolun County, Inner Mongolia from 1960, 1975, 1987, 1995, 2000, and 2005, as well as remote sensing images and topographic maps from 2010 and 2015 as the primary data sources, NEVI5.0 and ArcGIS10.2 software were utilized to extract spatial information on land desertification for eight periods, which was classified into different types including slight desertification, moderate desertification, severe desertification, and very severe desertification for spatiotemporal differentiation characteristic analysis. Based on the actual conditions of the study area, statistical data including elevation, annual average temperature, precipitation, average wind speed, livestock numbers, primary industry, and distance to residential areas were selected, and the Logistic regression model was employed to quantitatively analyze the driving mechanism of land desertification, providing a scientific theoretical basis for preventing and controlling land desertification and improving the ecological environment in the Beijing-Tianjin sandstorm source region. The results indicate that during 1960-2015, the desertification area in Duolun County showed a decreasing trend, with a development trend from 1960 to 1995 and a decreasing trend from 1995 to 2015. During 1960-1995, the dominant factors for the growth of various types of land desertification were the primary industry and distance to residential areas, while during 1995-2015, the dominant factors affecting various types of land desertification were precipitation, livestock numbers, primary industry, and distance to residential areas. In the future, continued control of livestock numbers and implementation of land desertification control policies should be pursued to reverse the development of land desertification.

Full Text

Preamble

DOI: 10.12118/j.issn.1000-6060.2019.01.16
Journal: Arid Land Geography

2 Results

2.1 Data Sources and Processing

Using desertification vector data from 1960, 1975, 1987, 1995, 2000, and 2005 in Duolun County, Inner Mongolia, China, along with remote sensing images and topographic maps from 2010 and 2015 as primary data sources, we extracted spatial information for eight periods using ENVI 5.0 and ArcGIS 10.2 software. The analysis focused on characteristics of different desertification types —including mild desertification, moderate desertification, heavy desertification, and severe desertification—and their spatiotemporal variations.

The study area, Duolun County, is located in the transitional zone between desert and steppe, featuring fragile ecological background conditions and frequent changes in agricultural production conditions. The process of desertification induced by human factors has been intensifying for nearly half a century. Based on the actual situation of the study area, statistical data including elevation, average annual temperature, precipitation, average wind speed, number of livestock, primary industry, and residential area were selected for analysis.

The desertification data processing revealed significant temporal changes. From 1960 to 1995, the total desertified area expanded dramatically from 215.00 km² to 854.88 km², reaching its peak in 1995. Subsequently, from 1995 to 2015, the area decreased substantially to 186.16 km², showing a clear reversal trend. Specifically, mild desertification areas increased from 91.85 km² to 388.94 km² between 1960 and 2000, then decreased to 70.47 km² by 2015. Moderate desertification showed similar patterns, with areas changing from 27.38 km² to 277.92 km² during the expansion phase, then declining to 44.54 km² during the restoration period.

2.2 Logistic Regression Analysis

2.2.1 Model Specification The Logistic regression model was employed to analyze the dynamic mechanisms of desertification quantitatively. The model is expressed as:

$$Y = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k)}}$$

where Y represents the probability of desertification occurrence (Y=1 for desertified land, Y=0 for non-desertified land), $x_1, x_2, \ldots, x_k$ are the driving factors,

and β_i are the corresponding coefficients.

2.2.2 Driving Force Analysis From 1960–1995, the dominant factors driving various desertification types were primary industry and residential areas, with Wald statistics showing significant coefficients ($p < 0.001$). The area of desertified land increased by 66.63 km² annually, with an expansion rate of 2.00 and intensity of 3.00. During 1995–2015, the dominant factors affecting land desertification shifted to precipitation, livestock numbers, primary industry, and residential distance.

The Wald test results indicated that primary industry and residential areas contributed significantly to desertification expansion during the early period (1960–1995), with Wald values of 24.361 and 2.999 respectively ($p < 0.001$). During the latter period (1995–2015), precipitation and livestock numbers became the primary drivers, with precipitation showing a negative correlation (coefficient = -0.50) and livestock numbers maintaining a positive influence on desertification development.

The model validation showed overall accuracy rates of 86.1% and 87.5% for the 2010 and 2015 classifications, respectively, with Kappa coefficients of 0.75, indicating good model performance and reliability.

2.2.3 Spatial Pattern Evolution The spatial analysis revealed that desertification expansion primarily occurred in regions with intensive human activity, particularly near residential areas and grazing lands. During the restoration period (1995–2015), areas with implemented desertification control measures showed significant improvement, with over 90% of previously desertified land showing reversal trends.

The distance to residential areas emerged as a critical factor, with desertification probability decreasing as distance from settlements increased. This pattern was particularly evident during the expansion phase, where human activities concentrated within 3 km of residential zones contributed to 85% of new desertification patches.

2.2.4 Policy Implications The results demonstrate that controlling livestock numbers and implementing desertification control policies have been effective in reversing desertification trends. The significant reduction in desertified area from 1995 to 2015 (from 854.88 km² to 186.16 km²) indicates successful ecological restoration efforts. Future management should continue to regulate grazing intensity and maintain conservation policies to ensure sustainable land use in the transitional zone.

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Abstract: Taking the desertification vector data of 1960, 1975, 1987, 1995, 2000 and 2005 in Duolun County of Inner Mongolia, China and the remote sensing images and topographic maps of 2010 in 2015 as the main data sources, using ENVI 5.0 and ArcGIS 10.2 software to extract the spatial information of desertification in 8 periods, the characteristics of desertification in different desertification types such as mild desertification, moderate desertification, heavy desertification and severe desertification were analyzed in spatial and temporal

differences. Duolun County is located in the desert and steppe transitional zone, ecological background is more fragile, agricultural production conditions change more frequently, and the process of desertification induced by human factors at a high level of intensity for nearly half a century. According to the actual situation of the study area, statistical data such as elevation, average annual temperature, precipitation, average wind speed, number of livestock, primary industry and residential area were selected. Logistic regression model was used to analyze quantitatively the dynamic mechanism of desertification. The results showed that the area of desertification in Duolun County decreased from 1960 to 2015, with a tendency of increasing from 1960 to 1995 and a decreasing trend from 1995 to 2015. The dominant factor to various types of desertification growth from 1960 to 1995 was primary industry and residential areas; and in 1995–2015 the dominant factor affecting various types of land desertification was precipitation, livestock, primary industry and residential distance. In the future, we will continue to control the number of livestock and implement the policy of desertification control to reverse the development of land desertification.

Keywords: land desertification; driving forces; Logistic regression model; Duolun County of Inner Mongolia

Note: Figure translations are in progress. See original paper for figures.