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Desertification and Its Driving Factors in the Ordos Plateau, 1986-2015: A Postprint

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Abstract

Based on Landsat satellite imagery from 1986 to 2015, this study employs multiple linear stepwise regression analysis to establish a model integrating climatic data and human activity data, and investigates the desertification process and its driving factors in the Ordos Plateau over the past 30 years. The research results indicate: From 1986 to 2015, the desertification in the Ordos Plateau showed an overall reversal trend, which can be divided into two developmental stages with the year 2000 as the turning point: from 1986 to 2000, the desertified area in the Ordos Plateau remained at a high level, with particularly severe desertification in the western and southern parts of the plateau; from 2001 to 2015, the desertified area gradually decreased with fluctuations, with the reduction concentrated in the eastern and southern parts of the plateau, but after 2012, the desertified area in the western part of the plateau showed a slight increasing trend again. Annual precipitation and rural population size are the most important driving factors affecting the desertification process in the Ordos Plateau, among which precipitation is most closely related to desertification, while the relationships between other factors and desertification are not significant.

Full Text

Preamble

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The Ordos Plateau, located in northern China (36°49'–40°53' N, 106°27'–111°27' E), covers an area of approximately 1.3×10^6 km². With a population of 5.46×10^6 in 2018, this region represents a typical area undergoing desertification processes in China. The study area encompasses about 6×10^4 km² of desertified land, characterized by a temperate continental monsoon climate with an average annual temperature of 5.5–9.6°C and precipitation ranging from 170–490 mm. Wind speeds average 2.1–3.3 m · s⁻¹, creating conditions conducive to both desertification and restoration dynamics.

[Figure 1: see original paper] Schematic of the research region

2. Methods

2.1 Data Sources and Preprocessing

Landsat satellite imagery was obtained from the USGS Earth Explorer (<https://earthexplorer.usgs.gov>) for the period 1986–2015, including TM data (1986–2011), ETM+ data (2012), and OLI data (2013–2015), all at 30 m spatial resolution. Images from the growing season (June–September) with cloud cover less than 10% were selected, yielding 240 scenes over the 30-year period.

Desertification classification was performed using the NDVI-based method. The NDVI threshold approach was applied using the formula $Y = (NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})$, where $NDVI_{max} = 0.91$ and $NDVI_{min} = 0.04$. Areas with vegetation cover $< 25\%$ were classified as desertified land, while areas with $> 25\%$ vegetation cover were classified as non-desertified land.

2.2 Regression Model Construction

A multiple linear regression model was developed to analyze relationships between desertification extent and potential driving factors. The model incorporated six independent variables: annual temperature (T), annual precipitation (M), average wind speed (W), total population (Q), sheep inventory (S), and industrial output value (I). The dependent variable (Y) represented desertified area.

The regression equation took the form: $Y = a_0 + a_1 x_1 + a_2 x_2 + \dots + a_n x_n$

Where a_0 is the constant term, a_1 through a_n are regression coefficients, and x_1 through x_n represent the driving factors. All statistical analyses were performed using ENVI 5.3 and Landsat processing tools.

3. Results

3.2.2 Model Performance and Significant Factors

The stepwise regression analysis identified precipitation and population as the most significant factors influencing desertification dynamics in the Ordos Plateau. The final model equation was:

$$Y = -0.2M + 0.23Q + 79.67 \quad (R^2 = 0.722, P < 0.001)$$

The model's F-statistic was 34.986 ($P < 0.001$), indicating statistical significance. Precipitation (M) and population (Q) together explained 72.2% of the variance in desertified area. The negative coefficient for precipitation (-0.20) indicates that increased rainfall contributes to desertification reversal, while the positive coefficient for population (0.23) suggests that rural population growth accelerates desertification processes.

Model correlation coefficients and significance levels

3.2.3 Precipitation Impact Analysis

Precipitation demonstrated the strongest relationship with desertification dynamics. Historical data show that during 1975–2000, precipitation changes were the primary climatic driver of desertification patterns. After 2000, increased precipitation contributed significantly to desertification reversal, particularly during 2001–2015 when annual precipitation increased at a rate of (cid : 228)/efgfw(cid : 155)(cid : 130)y9C (cid : 217)2001—2004 : 2006—2008 : 2011—2015 : efg(cid : 129)(cid : 130)(cid : 134)(cid : 147)(cid : 242)y(cid : 228)(cid : 138)(cid : 160)(cid : 135);8/(cid : 134)D(cid : 242)y 2012 : (cid : 153) : (cid : 160)(cid : 135);H : (cid : 146)(cid : 147) 'aDbcd † (cid : 255)(cid : 135)E(cid : 228)u(cid : 212)H : (cid : 255)(cid : 160)xy[22 /efg(cid : 129)(cid : 130)(cid : 158) mm · a¹. However, the relationship is complex, as extreme precipitation events can also exacerbate soil erosion in vulnerable areas.

The 30-year analysis revealed that precipitation variability accounted for substantial interannual fluctuations in desertified area, with pronounced effects during drought periods (2004–2005, 2009–2010) when desertification expansion rates reached \$\$. 2 0 1 0 – 2 0 1 5 : 'aDbcdefg(cid:129)(cid:130)(cid:136)h" ? 5. 4 1 × 1 0 4 k m 2 , ‡ = 3 0 a _fD(cid:127)(cid:128), (cid:152) 2 0 1 2 : 9(cid:153) 'a Dbcd" (cid:139)(cid:148)(cid:149)' efg(cid:129)(cid:130)(cid:154)' (cid:212)(cid:158)(cid:159)xy.st_G,H 1 9 8 6 : 9 _'aDbcdefg'† ,(cid:204). 3 0 a _' aDbcdefg(cid:129)(cid:130)9 2 0 0 0 : (cid:129)(cid:130)u(cid:212)(cid:159)yvw' xy.

G 3 1 9 8 6 – 2 0 1 5 : 'aDbcdefg' †(cid:148)(cid:243)LR Fig. 3 Spatial distribution map of desertification land in Ordos Plateau from 1986 to 2015. (cid:181) (cid:148) 3 4 ChinaXiv 合作期刊 G 4 1 9 8 6 – 2 0 1 5 : ' aDbcdefg=¥m(cid:221) F

fig. 4 Desertification impact factor of the Ordos Plateau from 1986 to 2015. $R^2 = 0.722$. The statistical relationship remained robust ($R^2 = 0.722$) across the entire study period, confirming precipitation as the dominant climate factor controlling desertification trends in the Ordos Plateau.

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Abstract: The Ordos Plateau is a typical area undergoing desertification in China. The desert areas of the Ordos Plateau between 1986 and 2015 were derived from remote sensing analysis and relationships between desertification area and potential driving factors, including climate and human activity, were analyzed using multivariate linear stepwise regression analysis. The results show that: (1) The year 2000 was the turning point at which the desertification of the Ordos Plateau first increased and then decreased. From 1986 to 2000, the Ordos Plateau showed general desertification expansion, especially in the west and south; during 2001-2015, the desertification area gradually decreased, with reduction mostly occurring in the eastern and southern parts of the plateau. After 2012, desert areas increasingly developed in the western part of the plateau. (2) Among the driving factors influencing the desertification of the Ordos Plateau, precipitation and population are the most significant, with precipitation being most closely related to desertification. Other factors show no significant relation to desertification. From 1986 to 2015, increased precipitation contributed to the reversal of desertification, while the rise of rural population accelerated the desertification process.

Keywords: desertification; driving factors; multiple linear regression; Ordos Plateau

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

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