Postprint: Analysis of Changes and Causes of Desertified Land in the Cuona Lake Section of the Qinghai-Tibet Railway

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Abstract

The impact of the construction of the Golmud-Lhasa section of the Qinghai-Tibet Railway on desertification changes along the railway corridor has been a focal point of concern. By employing geographic information systems and remote sensing monitoring techniques, and based on data including Landsat imagery, Google Earth imagery, and meteorological records from the Cuona Lake section, interpretation indicators were established through field surveys. Using a human-computer interactive visual interpretation approach, desertification land information for the Cuona Lake section of the Qinghai-Tibet Railway was extracted for 2001, 2008, and 2015, and the driving factors behind desertification changes were analyzed. Additionally, a buffer zone analysis was performed on desertification changes along the railway corridor. The results indicate: (1) From 2001 to 2008, the desertification land area increased by 2.21 km^2, while the degree of desertification exhibited a decreasing trend; from 2008 to 2015, the desertification land area decreased by 8.9 km^2, and the degree of desertification continued to decrease. (2) During 2001–2008, the increase in desertification land area was primarily associated with anthropogenic factors, whereas the decrease in desertification degree was mainly linked to natural factors. During 2008–2015, both the reduction in desertification land area and the decrease in desertification degree were predominantly attributable to anthropogenic factors. (3) Within a 2 km radius of the Cuona Lake section, changes in desertification degree were most significant, characterized primarily by a decreasing trend, suggesting that the Qinghai-Tibet Railway's impact on the surrounding environment extends to a range of 2 km.

Full Text

Preamble

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Abstract

The impacts of desertified land change (DLC) during the construction of the Qinghai-Tibet Railway from Golmud to Lhasa have given rise to important research significance. Based on Landsat imagery, Google Earth imagery, and meteorological data from the Co Nag Lake region along the Qinghai-Tibet Railway, this study uses RS and GIS technologies and conducts fieldwork to establish interpretation signs and construct a classification & grading system for DLC in the study area, and then employs visual interpretation method to extract DLC information for 2001, 2008, and 2015 respectively. The spatiotemporal evolution of DLC over the last 15 years is analyzed. The results show as follows: (1) In 2015, the desertified land was mainly sandy land, but the area of sandy gravel land was relatively small in the study area. The area of desertified land increased by 2.21 km^2 from 2001 to 2008, yet the degree of land desertification showed a declining trend. The desertified land decreased by 8.9 km^2 from 2008 to 2015, and the declining degree of land desertification continued. (2) From 2001 to 2008, the increase in desertified land area was related to the increase in the number of livestock such as yak and sheep. The decline of land desertification was mainly due to the increase of annual mean temperature and the decrease in annual mean wind speed. From 2008 to 2015, the decrease of desertified land and the alleviation of the degree of land desertification resulted from the gradual decrease in the number of livestock and the implementation of ecological restoration projects by the local government. Hence, human activities played an important role in the decline of land desertification in the 15 years. (3) The construction of the Qinghai-Tibet Railway generated a disturbance to the ecological environment in the study area. The scope of influence by the railway is about 2 km. While the engineering measures of controlling land desertification along the railway lines played an important role in alleviating the degree of land desertification. In short, the discussion of the factors including the impacts of railway construction on DLC can provide some scientific basis for the prevention of land desertification and for the rehabilitation of ecological environment.

Keywords: Qinghai-Tibet Railway; Co Nag Lake; desertification; natural factors; human factors

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1 Study Area

The study area is located in the Co Nag Lake region along the Qinghai-Tibet Railway, covering a total area of 604.23 km^2. The region is characterized by a typical plateau climate, with an average annual temperature of -1.3°C and annual precipitation of 411 mm. The extreme minimum temperature reaches -12.9°C, while the extreme maximum temperature is 8.0°C. The average annual wind speed in 2015 was 3.38 m/s, with prevailing westerly winds. The elevation of the study area is approximately 4,110 meters above sea level.

[Figure 1: see original paper] Sketch map of the study area

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2 Data and Methods

2.1 Data Sources

The primary data sources include Landsat satellite imagery, Google Earth high-resolution imagery, and meteorological observation data. The Landsat data comprises three time periods: 2001, 2008, and 2015, which correspond to the ETM+, TM, and OLI sensors respectively.

2.2 Data Processing

The Landsat imagery was preprocessed using ERDAS IMAGINE software for radiometric calibration and atmospheric correction. Geometric correction was performed using the Auto-sync module with reference to Google Earth imagery. The classification system for desertified land was established based on field survey data and visual interpretation keys. The desertification grading system includes five categories: non-desertified, slight, moderate, severe, and very severe. Visual interpretation method was employed to extract desertified land information for each time period.

The accuracy assessment showed an overall classification accuracy of 76%, with Kappa coefficient of $A(cid:137)(cid:247)h\ bc[(cid:144)!ty(cid:137)(cid:144)!](cid:229)35\ 67\ \ W?bc[(cid:144)!\#$. The interpretation results were validated through field surveys conducted in July 2015.

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3 Results

3.1 Desertification Status in 2015

In 2015, the total area of desertified land in the study region was 158.88 km^2, accounting for 26.29% of the total study area. The spatial distribution showed that sandy land was the dominant desertification type, while sandy gravel land occupied a relatively small proportion. The desertified land was primarily distributed in the northwestern and southeastern parts of the study area.

3.2 Temporal Changes in Desertified Land

From 2001 to 2008, the desertified land area increased by 2.21 km^2. However, the degree of desertification showed a declining trend during this period. The area of severe and very severe desertification decreased by 25.30% and 31.95% respectively, while moderate desertification increased by 35.54% and slight desertification increased by 7.21%.

From 2008 to 2015, the desertified land area decreased by 8.9 km^2, and the declining trend in desertification degree continued. The transfer matrix analysis revealed that 32.43% of severe desertified land was converted to moderate status, while 2.27% and 2.08% transitioned to slight and non-desertified categories respectively. Conversely, 54.48% of non-desertified land remained stable.

Transfer matrix of desertified land of different degrees in the study area (km^2)

3.3 Spatial Distribution Patterns

The spatial analysis indicates that desertification changes were closely related to geomorphological conditions and human activities. The most significant changes occurred in areas with gentle slopes and near water sources. From 2001 to 2015, the overall trend showed a gradual decrease in desertification severity, particularly in the eastern part of the study area.

3.4 Desertification Along the Railway Corridor

To analyze the impact of railway construction on desertification, buffer zones of 0.5 km, 1 km, 2 km, 5 km, and 10 km were established along both sides of the railway line. The results show that within the 0.5 km buffer zone, desertified land area decreased by 5.97 km^2 from 2001 to 2008, with severe desertification decreasing by 2.65 km^2 and moderate desertification decreasing by 3.32 km^2.

Within the 1-2 km buffer zone, the changes were less pronounced. From 2001 to 2008, very severe desertification decreased by 0.08 km^2, while severe and moderate desertification decreased by 0.71 km^2 and 0.09 km^2 respectively. From 2008 to 2015, very severe desertification continued to decline by 0.56 km^2, and moderate desertification decreased by 0.31 km^2.

The analysis demonstrates that the railway's impact on desertification is most significant within a 2 km range, beyond which the influence gradually diminishes.

Desertified land areas of various types in different buffer zones within 2 km on both sides of railway line

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4 Discussion

4.1 Natural Factors

Climate change plays a crucial role in desertification dynamics. From 2001 to 2008, the annual mean temperature increased while annual precipitation remained relatively stable, contributing to the reduction in desertification severity.

The annual mean wind speed decreased from 3.52 m/s in 2001 to lower values in 2008 and 2015, reducing wind erosion intensity.

The relationship between temperature, precipitation, and desertification is complex. Higher temperatures can enhance vegetation growth in this high-altitude region, while reduced wind speed directly decreases sand transport capacity. The combined effect of these climatic factors created favorable conditions for desertification reversal.

4.2 Human Factors

Human activities have significantly influenced desertification trends in the study area. From 2001 to 2008, the livestock population increased substantially, with the number of sheep and goats rising by 19.77×10^{4} heads. This overgrazing pressure contributed to vegetation degradation and desertification expansion.

However, from 2008 to 2015, the livestock population decreased by 26.14×10^{4} heads compared to 2008 levels, due to implementation of ecological restoration policies and grazing prohibition measures. This reduction in grazing pressure, combined with active restoration efforts, led to significant desertification reversal.

The construction of the Qinghai-Tibet Railway also impacted desertification patterns. Engineering measures such as sand barriers and vegetation restoration along the railway corridor effectively controlled sand damage and contributed to desertification alleviation within the 2 km buffer zone.

[Figure 4: see original paper] Number of livestock varied from 2001 to 2015 in Amdo County

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5 Conclusion

Over the past 15 years (2001-2015), the desertified land in the Co Nag Lake region along the Qinghai-Tibet Railway has shown a dynamic change pattern. The area increased slightly from 2001 to 2008, then decreased significantly from 2008 to 2015. The degree of desertification consistently showed an alleviating trend throughout the study period.

Natural factors, particularly climate change characterized by warming temperatures and reduced wind speed, created favorable conditions for desertification reversal. Human factors, including livestock population changes and ecological restoration measures, played a decisive role in the actual desertification dynamics. The railway construction generated localized environmental disturbance but also implemented effective control measures within a 2 km influence zone.

The study demonstrates that integrated natural and anthropogenic factors determine desertification processes in this plateau region. Future desertification control should continue emphasizing ecological restoration and sustainable land management practices, particularly grazing regulation and sand control engineering along transportation corridors.

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