OPEN ACCESS
PAPER

Mongolian Journal of Geography and Geoecology - MJGG

Received: 08 May 2025; Accepted: 12 June 2025; Published online: 1 September 2025
https://doi.org/10.5564/mjgg.v62i46.4107

Ecological security and green development on the Mongolian plateau: A China–Mongolia collaborative response to climate change

Hao Cheng[1], Xinyuan Wang[1,2], Fujia Li[1,3,*], Dashtseren Avirmed [4], Wenlong Li[5]

[1]*Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China*
[2]*University of Chinese Academy of Sciences, Beijing 100049, China*
[3]*Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China*
[4]*Institute of Geography and Geoecology, Mongolian Academy of Sciences, Ulaanbaatar 15170, Mongolia*
[5]*College of Resources and Environmental Economics, Inner Mongolia University of Finance and Economics, Hohhot, 010070, China*

***CORRESPONDING AUTHOR**
Fujia Li
lifj@igsnrr.ac.cn

CITATION
Hao Ch, Xinyuan W, Fujia L, Dashtseren A, Wenlong L (2025) Ecological Security and Green Development on The Mongolian Plateau: A China–Mongolia Collaborative Response to Climate Change. *Mongolian Journal of Geograhy and Geoecology,* 62(46), 1–7.
https://doi.org/10.5564/mjgg.v62i46.4107

COPYRIGNT
© Author(s), 2025
https://creativecommons.org/licenses/by/4.0/

ABSTRACT

The Mongolian Plateau plays a key role in the geopolitical and ecological structure of Northeast Asia. In recent years, the combined effects of climate change and human activities have intensified ecological risks in the region, especially land degradation and sandstorms, which have had significant impacts on both China and Mongolia. This paper reviews two decades of work by the authors' team on the Mongolian Plateau, including research on pattern characterization, mechanism analysis, and optimization strategies related to land cover, ecosystem vulnerability, ecological-economic zoning, investment environment, industrial structure, and transport infrastructure. Building on this foundation, the paper identifies four major priorities for future cooperation: risk assessment and spatiotemporal evolution pattern of ecological security risk in the Mongolian Plateau under climate change, influencing factors and driving mechanism of ecological risks in the Mongolian Plateau, China-Mongolia joint construction plan for ecological security shield in the Mongolian Plateau, and green Development Model and Typical Demonstration of Mongolian Plateau. These future cooperation efforts aim to provide essential scientific and technological support for desertification control, land degradation prevention, sandstorm risk reduction, and the protection of biodiversity and ecosystem stability on the Mongolian Plateau. In addition, this study holds important scientific value for addressing global climate change, promoting sustainable development in transboundary regions, and mitigating large-scale ecological risks.

KEYWORDS

Ecological security shield construction, Green development mode, Ecological environmental risks, China-Mongolia cooperation, Mongolian Plateau

1. INTRODUCTION

The Mongolian Plateau holds a key position in the geopolitical and ecological structure of Northeast Asia. The inland region of Mongolia, which lies at the core of the plateau, is part of the active wind–sand zone in northern China. It is characterized by fragile and sensitive ecosystems and experiences severe climate change. In recent years, the warming and drying trend has intensified, and the added pressure from human activities has further increased ecological risks. These risks have not only caused significant ecological impacts within Mongolia but have also posed serious transboundary environmental threats to China.

Climate change and sandstorms on the Mongolian Plateau have had significant impacts on regional ecosystems and socio-economic development, as emphasized by a growing body of research. Observational data show that between 1982 and 2015, approximately 12.6% of the world's arid regions experienced ecological degradation, affecting more than 200 million people [1]. Studies on the Mongolian Plateau indicate that the rate of warming in this region has significantly exceeded the global average, accompanied by a decreasing trend in precipitation. Since the 1960s, these changes have led to ecosystem imbalances, water scarcity, and grassland degradation [2]. One study reviewed a once-in-a-decade sandstorm event in March 2021, which caused widespread ecological damage across Mongolia and neighboring countries [3]. In response to these challenges, scholars have called for integrated approaches that couple ecological and social systems to build ecological security barriers and promote green development pathways[4]. Collectively, these findings underscore the high sensitivity of the Mongolian Plateau's ecosystems to global climate change and the urgent need to strengthen regional cooperative governance.

However, due to the complex impacts of climate change and human activities on the Mongolian Plateau, there is still no clear conclusion regarding the causes, transmission mechanisms, and driving factors of ecological risks such as sandstorms. Existing studies lack innovative research focused on the formation, mechanisms, and impacts of transboundary ecological risks, as well as on joint international prevention strategies and adaptive development models. There is also a serious shortage of practical and verifiable models for China-Mongolia joint construction of ecological security barriers and green development approaches that achieve both ecological and economic benefits. This gap in innovation and empirical research falls far short of meeting the urgent scientific and technological needs for ensuring ecological security and promoting green, sustainable development on the Mongolian Plateau.

Therefore, understanding the ecological risks of land degradation and sandstorms on the Mongolian Plateau under climate change, along with their formation mechanisms, is an urgent priority. It is essential to scientifically construct a comprehensive ecological security barrier for the plateau, establish green development models suited to regional conditions, and ensure their practical implementation and promotion. This is a pressing and realistic need for safeguarding ecological security on the Mongolian Plateau—especially in northern China. It is also a key scientific issue of high concern to both governments and the public, requiring targeted cross-border cooperation between scientists from both countries.

2. RESEARCH METHODS

2.1. Study Area

The Mongolian Plateau encompasses Mongolia, southern Russia, and parts of Inner Mongolia, Gansu, and Xinjiang in China. In recent years, the region has undergone intensified warming and drying trends, further exacerbated by human activities, leading to heightened ecological risks. As a transboundary zone of active aeolian processes across northern China and Mongolia, it poses significant ecological challenges to both countries. In response, our research team has conducted a series of studies focusing on spatial pattern, mechanism analysis, and optimized regulation for ecological safety and sustainable development in the typical regions of Mongolian Plateau.

2.2. Methods

Over the past ten years, we conducted a comprehensive study of the Mongolian Plateau using a range of analytical methods. It included ecological environmental quality dynamic index, human–environment coupled system vulnerability evaluation index, two-tier ecological–economic zoning scheme, integrated impact index evaluation model, geographically weighted regression model, Geodetector model, two-way fixed effects model, and so on. These models have provided us with advanced technical methods for conducting in-depth analysis on spatial pattern, mechanism analysis, and optimized

regulation for ecological safety and sustainable development in the typical regions of Mongolian Plateau.

3. RESULT

In the past two decades, my research team and I have carried out a series of studies on the Mongolian Plateau. These studies focus on the spatial pattern, mechanism analysis, and optimized regulation for ecological safety and sustainable development in the typical regions of Mongolian Plateau.

3.1. Spatial Pattern

The Mongolian Plateau, as a typical arid and semi-arid ecological zone in the Eurasian continent, is a key area for understanding the evolution of the reconstruction of regional human–environment relationships. To better understand the spatial characteristics of ecological and economic structure changes and the coupling between ecology and economy, we have carried out systematic study on the spatial pattern characterization of the Mongolian Plateau and its transboundary areas from different scales and perspectives.

Based on global remote sensing and socio-statistical data from 1992 to 2020, we analyzed the land use change and its eco-environmental effects in 435 counties across the Mongolian Plateau. The results revealed complex trends of grassland degradation, desertification spread, and the expansion of agri-pastoral transition zones (Figure1).

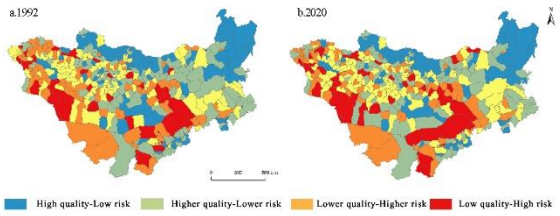

Figure1. Spatial pattern of eco-environmental quality index on the Mongolian Plateau

We have developed an indicator system based on climate, topography, soil, and socio-economic data. Using this system, we quantified the spatial distribution of ecological vulnerability in Mongolia (**Figure 2**.), along the China-Mongolia-Russia cross-border transport corridor[5], and in the Heilongjiang–Amur River Basin.

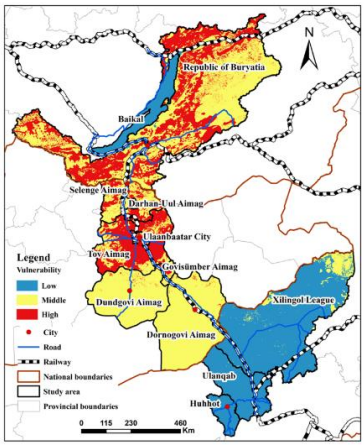

Figure 2. Vulnerability spatial pattern of China-Mongolia-Russia cross-border transport corridor

Taking into account factors of terrain, climate and development intensity, we analyzed the combination of resource endowments and economic characteristics in different regions of the China-Mongolia-Russia economic corridor, as well as their spatial differentiation patterns [6].

We used the ESE-PRT model to analyze the investment environment of 22 provincial-level units in Mongolia, and revealed the ecological and social factors were the key factors on the regional investment environment [7].

In terms of transport infrastructure development, we built a regional economic–social–ecological–transport assessment model (ESET model) to quantitatively evaluate the development levels of the four subsystems [8] and the degree of coupling coordination between transportation infrastructure construction (TIC) and ESE development (Figure 3). We also developed an Integrated Impact Index Evaluation Model (IIIEM) to assess the impact indices of various influencing factors related to the construction of the China-Mongolia-Russia high-speed railway, and revealed their spatial distribution patterns [9]. In addition, we constructed an ecological risk assessment model for cross-border railways, highways, and oil and gas pipelines along the China-Mongolia-Russia economic corridor, dividing the area into high, medium, and low ecological risk zones. The results showed that ecological risks in the corridor are distributed along "two belts and one line": the China-Mongolia-Russia cross-border transport belt is a high-risk zone for desertification, while the China-Russia cross-border transport belt and the China-Russia oil pipeline corridor are high-risk zones for permafrost degradation [10].

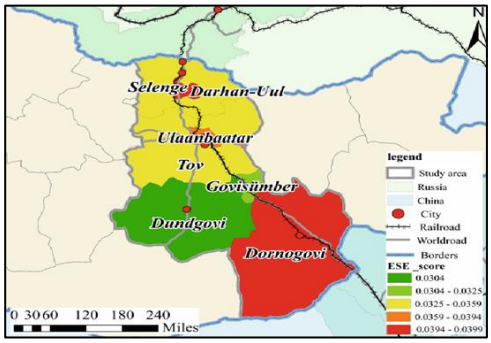

Figure 3. The degree of coupling coordination between TIC and ESE development

3.2. Mechanism Analysis

The evolution of spatial patterns reflects complex natural and human-driven mechanisms. The transformation of the social-ecological system on the Mongolian Plateau is the result of multiple interacting factors, including policy orientation, resource exploitation, infrastructure development, and climate change. A deeper analysis of these core mechanisms helps identify key driving factors and understand system response processes, thereby improving the scientific basis and precision of regional development strategies.

Based on the systematic analysis of land use change and eco-environmental effects in 435 counties across the Mongolian Plateau, we found that the influencing factors of eco-environmental quality change are ranked as follows: natural factors > economic factors > social factors. The combined influence of natural, social, and economic factors has shaped a multi-dimensional driving pattern characterized by a dynamic interplay of forces, which continuously reconstructs the spatial pattern of eco-environmental quality on the Mongolian Plateau (Figure 4).

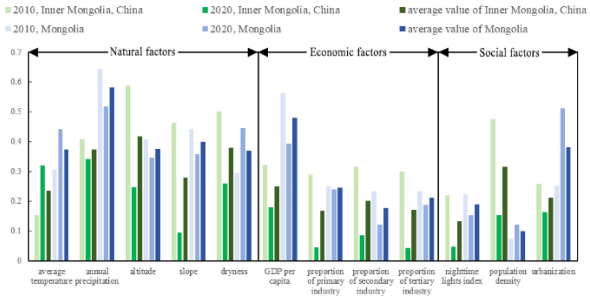

Figure 4. Mechanisms driving changes in ecosystem quality on the Mongolian Plateau

Based on the provincial-level spatial analysis of vulnerability in Mongolia, we examined the ecological vulnerability patterns under different scenarios of change in three key factors: population, GDP, and livestock numbers. After completing the vulnerability analysis of the China-Mongolia-Russia cross-border transport corridor, we systematically analyzed and identified the key risk factors in different regions [5].

In terms of ecological-economic zoning, we systematically identified the influencing mechanisms of factors such as landform, climate, and industrial structure on regional differentiated development through the zoning process [6].

We used the ESE-PRT model to explore the formation mechanisms of the investment environment from the perspectives of institutions and resources. We identified four types of investment zones and further revealed the priority industries for investment and the main investment risks in the priority investment areas [7].

We used a two-way fixed effects model to systematically examine the relationship between the mining sector's share of GDP and the Human Development Index (HDI). The results show that the development of the mining industry has promoted economic growth, job creation, and infrastructure development, which in turn has improved education, healthcare, and living standards (Table 1).

Table 1. The mechanism analysis of mining and the Human Development Index

Variable	(1) HDI	(2) Life	(3) Edu	(4) Eco
mining	0.0854***	0.006	0.0341***	0.206***
	(0.008)	(0.0056)	(0.0119)	(0.0200)
urban	-0.0103	-0.0003	0.0421***	0.0098**
	(0.0226)	(0.0014)	(0.0090)	(0.0041)
tele	0.0172***	-0.0004	0.0192*	-0.0051
	(0.0027)	(0.0012)	(0.0101)	(0.0057)
library	0.0059*	-0.0032	0.0153	0.0561***
	(0.0035)	(0.0048)	(0.0158)	(0.0186)
doctor	0.0259***	0.0177	-0.0783	0.00701
	(0.0074)	(0.0127)	(0.0493)	(0.0424)
_cons	0.410***	0.764***	0.315***	0.226**
	(0.0427)	(0.0259)	(0.108)	(0.0991)
N	440	440	440	440
R^2	0.938	0.983	0.961	0.958

3.3. Optimized Regulation

Based on a systematic understanding of patterns and mechanisms, proposing region-specific and zone-based policy recommendations is key to supporting green development and cross-border cooperation in the region.

Based on the analysis of vulnerability patterns and driving factors in the China-Mongolia-Russia cross-border transport corridor, we proposed an ecological risk prevention and control zoning plan, along with region-specific policy recommendations for different risk zones [5] (Figure 5). For the Heilongjiang–Amur

River Basin, we conducted an in-depth analysis of the Mongolian part of the basin and proposed cooperative strategies among China, Mongolia, and Russia to mitigate ecological vulnerability.

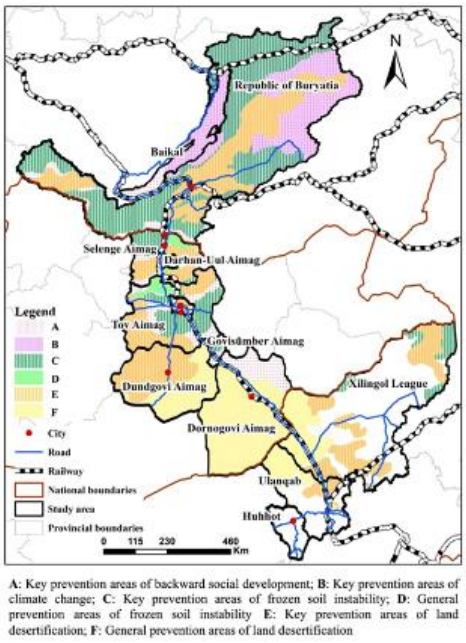

Figure 5. Vulnerability prevention and control zoning in China-Mongolia-Russia cross-border transport corridor

In terms of ecological-economic zoning, we divided the China-Mongolia-Russia economic corridor into 19 sub-zones (Figure 6), and conducted comprehensive comparative analysis of their ecological, economic, and social characteristics, as well as their spatial differentiation patterns. Following the principle of green and sustainable development, we categorized the sub-zones into three types: optimized development zones, key development zones, and conservation development zones. We then proposed green development strategies tailored to each zone type [6].

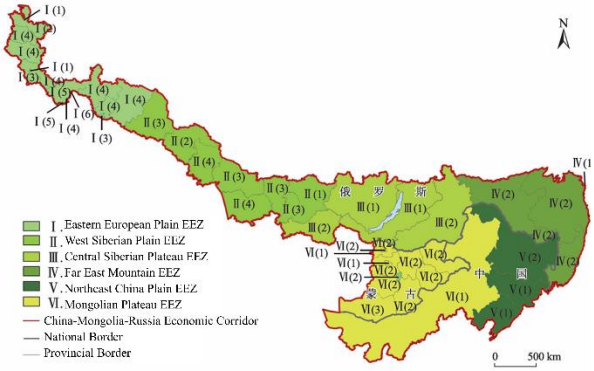

Figure 6. Eco-economic zones (EEZ) and sub eco-economic zones in the China-Mongolia-Russia economic corridor

Based on the assessment of the vulnerability of the human-land coupling system in each province of the Mongolian Plateau from 2002 to 2022, we predicted the vulnerability of the human-land coupling system in 2030 under different development scenarios of population and animal husbandry. We also comparative analyed the three different development scenarios and proposed the countermeasures for future optimization and regulation (Figure 7).

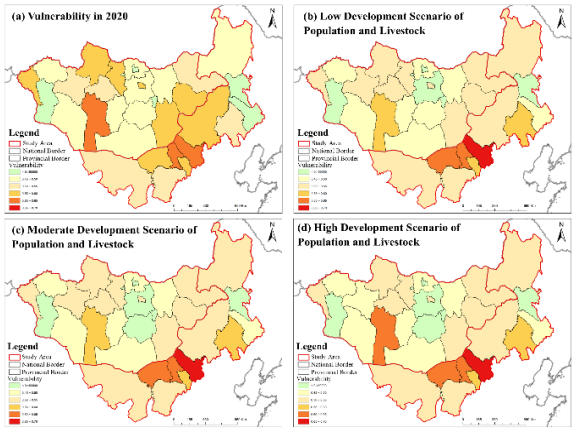

Figure 7. Provincial-Level Vulnerability Assessment and Simulation Prediction of the Mongolian Plateau

4. DISCUSSION

Based on a comprehensive scientific expediton and continuous research over the past two decades on the Mongolian Plateau, we proposed the key research prospect for ecological security shield construction and green development of Mongolian Plateau in the future.

4.1. Risk assessment and spatiotemporal evolution pattern of ecological security risk in the Mongolian Plateau under climate change

Based on comprehensively utilizing 3S technology and big data mining, combined with site monitoring and scientific expedition, it will systematically analyze the characteristics of climate change, the spatiotemporal patterns and evolution laws of ecological environment elements in the Mongolian Plateau over the past 30 years.

Scientifically evaluate the main types of ecological security risks in the Mongolian Plateau (such as land degradation, sandstorms, etc.) and their impact degree. Reveal the formation process, spatiotemporal evolution pattern, regional

differentiation laws of major ecological security risks such as land degradation and sandstorms.

4.2. Influencing factors and driving mechanism of ecological risks in the Mongolian Plateau

Using econometric models such as Factor Analysis Approach, Granger Causality Test Model, and Logistic Regression Analysis, it will analyze the impact of key natural factors (such as climate, hydrology, biology, natural disasters, atmospheric circulation, etc.) and key human activities (such as urbanization, animal husbandry development, mineral resource development, residential lifestyle, etc.) on the regional ecological security risks.

Determine the key influencing factors of major ecological security risks such as land degradation and sandstorms in the Mongolian Plateau. Reveal the driving mechanisms of various influencing factors on the major ecological security risks.

4.3. China-Mongolia joint construction plan for ecological security shield in the Mongolian Plateau

Construct a system dynamic model for the evolution of ecological security risks in the Mongolian Plateau, simulate the trend of ecological security risk evolution, and define the different prevention zones for ecological security risk, such as sand and dust source zones, transmission channel zones, secondary dust emission zones, disaster undertaken zones, etc.

Focusing the actual prevention and control needs of the different prevention zones for ecological security risk, propose China-Mongolia joint construction plan for ecological security shield in the Mongolian Plateau, through the construction of barriers, corridors, protected areas, sampling points, monitoring stations, etc.

4.4. Green Development Model and Typical Demonstration of Mongolian Plateau

In order to respond to climate change and achieve sustainable development of the Mongolian Plateau, it not only need to jointly construct the ecological security shield, but also improve human production and lifestyle, and propose a green development mode for the Mongolian Plateau. Adopt a circular economy development mode in mining areas, an ecological urban construction mode in residential areas, and a co-future mode of humans and nature in nature reserves areas. Propose a construction plan for the typical demonstration site of ecological security shield construction and green development mode in the Govisumber Province of Mongolia.

5. CONCLUSION

This study aims to address pressing ecological and developmental challenges in the Mongolian Plateau through a transboundary perspective.

Reveal the spatiotemporal evolution pattern, regional differentiation laws, and driving mechanisms of major ecological security risks such as land degradation and sandstorms in the Mongolian Plateau, and propose a plan for jointly constructing ecological security shield between China and Mongolia.

Propose a China-Mongolia cooperation mode for green development on the Mongolian Plateau responding to climate change, and construct a typical green development demonstration on the Mongolian Plateau.

The findings are expected to provide scientific support for regional ecological governance and sustainable development cooperation between the two countries.

ACKNOWLEDGMENTS

This research was funded by the National Key Research and Development Program of China - Science & Technology Cooperation Project of Governments (No. 2023YFE0111300 and No. 2024YFE0113800), Science & Technology Fundamental Resources Investigation Program (No. 2022FY101903).

REFERENCES

[1] A. L. Burrell, J. P. Evans, and M. G. De Kauwe, "Anthropogenic climate change has driven over 5 million km2 of drylands towards desertification," *Nature Communications*, vol. 11, p. 3853, 2020. Available: doi: 10.1038/s41467-020-17710-7

[2] H. Zhao, B. Qiao, H. Liu, et al., "Lake water storage changes and their cause analysis in Mongolia," Scientific Reports, vol. 14, p. 23536, 2024. Available: doi: 10.1038/s41598-024-75166-x

[3] J. Han, H. Dai, and Z. Gu, "Sandstorms and desertification in Mongolia, an example of future climate events: a review," *Environmental Chemistry Letters*, vol. 19, pp.

4063–4073, 2021. Available: doi: 10.1007/s10311-021-01285-w

[4] K. Kakinuma, A. Yanagawa, T. Sasaki, et al., "Socio-ecological interactions in a changing climate: a review of the Mongolian pastoral system," *Sustainability*, vol. 11, no. 21, Art. no. 5883, 2019. Available: doi:10.3390/su11215883

[5] X. Wang, H. Cheng, F. Li, et al., "Vulnerability assessment and optimization countermeasures of the human-land coupling system of the China-Mongolia-Russia cross-border transportation corridor," *Sustainability*, vol. 15, no. 16, Art. no. 19, 2023. Available: doi:10.3390/su151612606

[6] S. Dong, T. Boldanov, J. Li, et al., "Study on the ecological-economic zoning of the China-Mongolia-Russia economic corridor," *Geographical Research*, vol. 40, no. 11, pp. 2949–2966, 2021.

[7] Q. Liu, F. Li, Y. Zhuang, et al., "Evaluation of the investment environment and investment strategies of provincial-level administrative units in Mongolia," *Geographical Research*, vol. 40, no. 11, pp. 3046–3062, 2021.

[8] X. Shuangjie et al., "Coordinated degree assessment on transport infrastructure construction with regional economic-socio-ecological development: a study of the areas along the main traffic line in Mongolia," in Resources, Environment and Regional Sustainable Development in Northeast Asia, I. N. Vladimirov, M. Jiang, and P. Y. Baklanov, Eds. Cham, Switzerland: Springer, 2023. Available: doi:10.1007/978-3-031-28978-1_20

[9] S. Dong, Y. Yang, F. Li, et al., "An evaluation of the economic, social, and ecological risks of China-Mongolia-Russia high-speed railway construction and policy suggestions," *Journal of Geographical Sciences*, vol. 28, pp. 900–918, 2018. Available: doi: 10.1007/s11442-018-1512-y

[10] S. Dong, Y. Li, F. Li, et al., "Ecological risk zoning and countermeasures for transport and pipeline construction in the China-Mongolia-Russia economic corridor," *Bulletin of Chinese Academy of Sciences*, vol. 36, no. 2, pp. 141–149, 2021.