



Dynamic Monitoring of Long-term, Fine-grained Ecological Vulnerability in the Hohhot-Baotou-Ordos-Yulin Urban Agglomeration

Chunqiang Li, Shanchuan Guo, Peijun Du*

School of Geography and Ocean Science, Nanjing University, Nanjing, 210023, China.

INTRODUCTION

Rapid urbanization and climate change are exacerbating ecological vulnerability in dryland urban agglomerations, posing risks to sustainability and ecosystem stability. Currently, relatively little research focuses on the ecological vulnerability of dryland urban agglomerations, especially comprehensive assessments that consider soil salinity and biodiversity indicators. In addition, persistent technological gaps in large-scale, fine-grained and long-term monitoring hinder a comprehensive understanding of vulnerability patterns in these fragile regions.

METHOD

To investigate the underlying mechanism of dynamic changes in ecological vulnerability of dryland urban agglomerations, we developed a long-term, fine-grained assessment framework for dryland ecological vulnerability and its driving mechanisms by leveraging the GEE platform and machine learning (Fig. 1). First, six key indicators derived through remote sensing simplified the traditional complex VSD framework to construct a novel dryland ecological vulnerability index (DEVI). Spatiotemporal patterns were then analyzed to identify historical trends and predict future sustainability. Finally, XGBoost was coupled with SHAP method to model and visualize the impact of vulnerability factors.

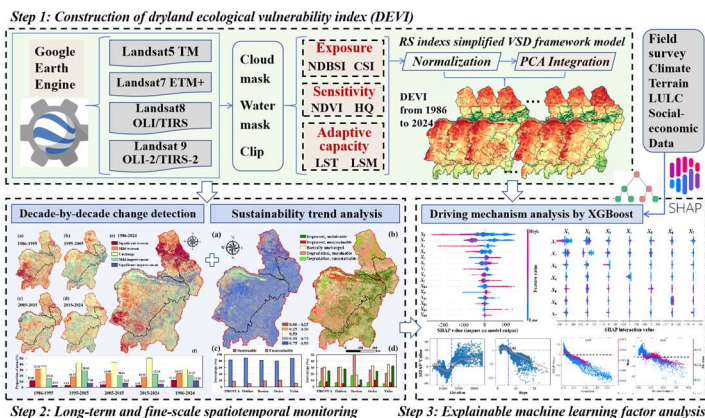


Fig. 1. Methodology flowchart of this study.

MAJOR RESULT

The results reveal distinct spatiotemporal patterns of ecological vulnerability in HBOYUA over nearly 40 years (Fig. 2). Initially, vulnerability worsened but then improved due to the implementation of ecological restoration projects like soil erosion control and afforestation. However, persistent vulnerability in such areas as the southwestern Ordos Plateau and northern Inner Mongolia Plateau highlight the imbalance in current ecological governance efforts.

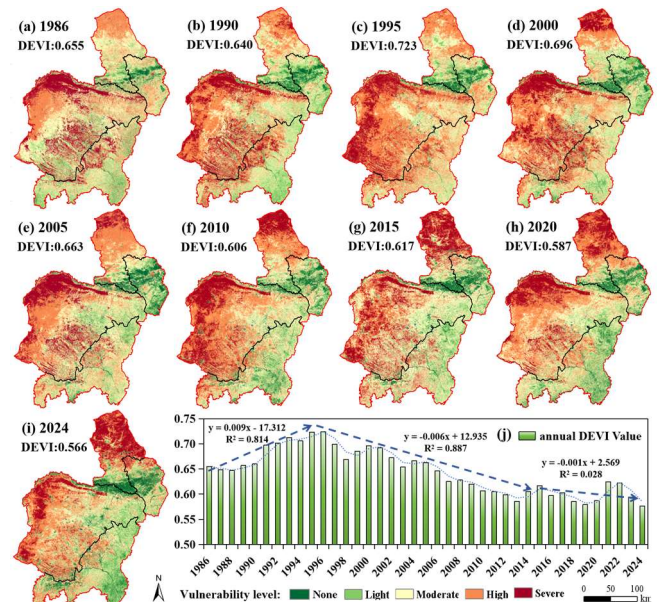


Fig. 2. Spatial pattern evolution of vulnerability in HBOYUA (1986–2024). (a-i) DEVI distributions at 5-year intervals; (j) Annual DEVI temporal changes.

The study also identified thresholds and interaction effects for key driving factors, delineated new ecological management zones (Fig. 3), and offered feasible suggestions for regional ecological restoration. Moreover, the observed spatial heterogeneity and dynamic changes in vulnerability emphasized the necessity of developing region-specific management strategies. These findings offer scientific guidance for optimizing ecological governance in arid urban regions and contribute valuable new perspectives to vulnerability assessment research.

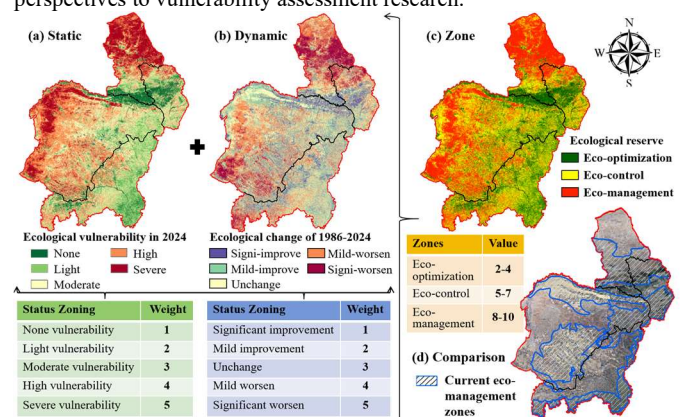


Fig. 3. Vulnerability control zones in HBOYUA. (a) Status and weighting of the static ecological vulnerability in 2024; (b) Dynamics of the vulnerability and its weighting; (c) Overlay result and identified ecological vulnerability protection zones; (d) Comparison with the current ecological management zones.

PUBLICATION

Related work has been written as an academic paper titled "Dynamic monitoring of fine-grained ecological vulnerability in dryland urban agglomerations integrating novel remote sensing index and explainable machine learning", which has been submitted to the international journal *GIScience & Remote Sensing* (Under Review).