

doi: 10.52370/TISC26501BY

TOURISM EXPANSION AND SUSTAINABLE DESTINATION TRANSFORMATION IN ECOLOGICALLY FRAGILE PLATEAU

Bo Yang¹; Jiawei Wu²; Anna Miao³

Abstract

This study investigates sustainable destination transformation on the Qinghai–Tibet Plateau from 2013 to 2023. By analyzing tourism expansion, land-use change, and habitat quality, we explore the balance between development and protection in fragile regions. Results show that tourism activities are strongly clustered in the eastern and southern plateau, driving a 51.59% expansion of construction land. Although regional habitat quality is stable (index 0.603), localized degradation has intensified near major destination nodes. The driving mechanism has shifted from nature-dominated to a socio-ecological co-driven system. We propose a differentiated governance framework across core, transition, and marginal zones to align tourism intensity with ecological capacity. The findings highlight that ecological integrity is essential to destination quality, offering a path for sustainable transformation in high-altitude destinations.

Key Words: Qinghai–Tibet Plateau, tourism expansion, habitat quality, destination transformation, differentiated governance

JEL classification: Z32, Q56, R58

Introduction

Tourism growth in ecologically fragile regions is a "double-edged sword": it promotes revitalization, infrastructure, and visibility while

¹ Bo Yang, PhD, Associate Professor, College of Tourism, Northwest Normal University, 967 Anning East Road, Lanzhou, Gansu, 0931-7971701, yangbo907@126.com

² Jiawei Wu, Master's Candidate, College of Tourism, Northwest Normal University, 967 Anning East Road, Lanzhou, Gansu, 0931-7971701, jerry_wu2631@163.com

³ Anna Miao, Master's Candidate, College of Tourism, Northwest Normal University, 967 Anning East Road, Lanzhou, Gansu, 0931-7971701, 17568933579@163.com

pressuring natural systems with limited carrying capacity. In high-altitude destinations, alpine environments are especially sensitive to climate variability and development pressure (Tang et al., 2022; Lin et al., 2024; Parvar & Salmanmahiny, 2025). Balancing tourism growth with ecological protection is therefore central to sustainable destination transformation.

Although research on habitat quality, land-use change, and tourism-related ecological impacts has expanded, a governance gap remains. Studies using InVEST or GeoDetector often emphasize technical assessment or single-factor drivers instead of destination transformation (Wang & Cheng, 2022; Jiang et al., 2024; Cao et al., 2024; Wu et al., 2023). Habitat quality reflects ecosystem capacity to sustain biodiversity and functions under disturbance (Hall et al., 1997; Polasky et al., 2011). A governance lens is needed to design differentiated responses to non-linear tourism impacts.

The Qinghai–Tibet Plateau (QTP), the “Third Pole of the Earth,” is an ideal case. As a strategic ecological barrier for China and Asia, it also received more than 100 million visitors in 2023. Transport and infrastructure improvements have clustered tourism services, bringing benefits while increasing pressure on land-use systems and ecological stability (Nie et al., 2023; Tong et al., 2025). The 51.59% rise in construction land highlights the need to align tourism intensity with ecological capacity.

This study develops a framework for sustainable destination governance by examining QTP reorganization from 2013 to 2023. Using 152,491 tourism POIs, land-use remote sensing, and socio-economic variables, it applies KDE, the InVEST Habitat Quality Model, and GeoDetector (Belej, 2021). It examines tourism concentration, land-use change, habitat degradation, and the shift from nature-dominated to socio-ecological co-driven mechanisms, then proposes differentiated governance.

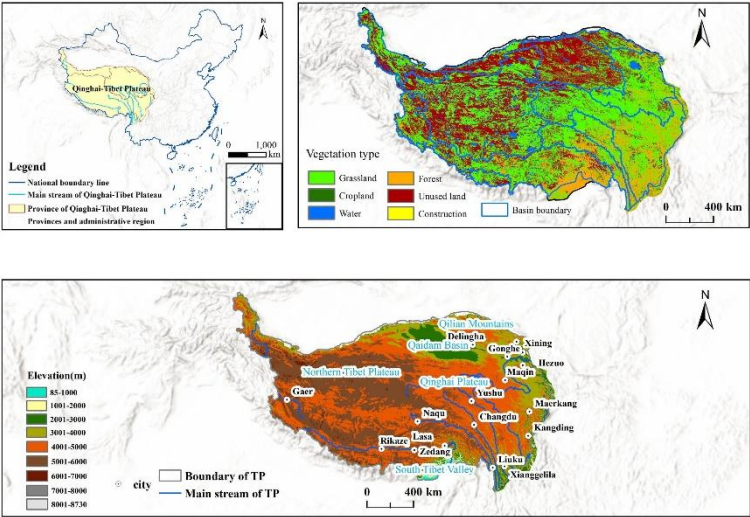
Study area and methods

Study area

The QTP covers about 2.79×10^6 km², averages above 4,000 m in elevation, and functions as a strategic ecological barrier for China and Asia. The study includes 251 county-level units across alpine meadows,

forests, and wetlands. Tourism exceeded 100 million visitors in 2023 and clusters along transport corridors. Balancing this demand with 377 nature reserves covering 35% of the plateau is a major challenge.

Figure 1: *Study area map*



Source: *Compiled by the authors based on the Administrative Boundaries Data from the National Tibetan Plateau Science Data Center (n.d.) and Copernicus DEM from OpenTopography (n.d.).*

Data sources

This study uses 2013, 2018, and 2023 datasets to capture destination reorganization. Land-use data came from the Chinese Academy of Sciences; topographic and meteorological data from OpenTopography and the National Tibetan Plateau Data Center; and socio-economic indicators from GDP and LandScan products. Tourism intensity was measured with 152,491 AutoNavi POIs. All data were standardized to a 1 km grid.

Analytical framework

The study links human activity intensity with ecological sensitivity to assess tourism expansion and sustainable transformation.

Kernel Density Estimation (KDE) was applied to tourism POIs to identify spatial clusters. The resulting tourism intensity surface divided the plateau

into core, transition, and marginal zones, creating a functional destination hierarchy beyond administrative boundaries.

The InVEST Habitat Quality Model assessed ecological responses to development pressure by integrating land-use transitions and threat factors, including cropland, urban land, and construction land, to estimate ecosystem capacity under human disturbance.

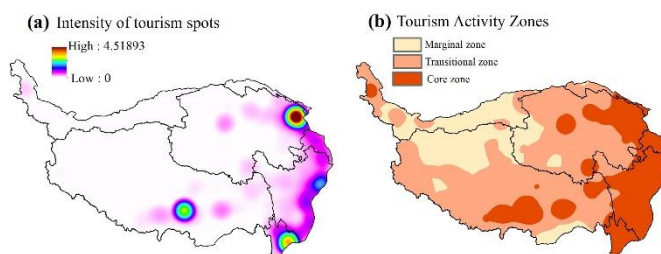
GeoDetector was used to explain habitat dynamics by measuring the *q*-values of 13 natural, socio-economic, and tourism variables. Interaction detection identified how combined effects, such as annual precipitation and tourism facility density, shape the evolving socio-ecological system.

Results and discussion

Tourism spatial concentration and destination hierarchy

Tourism elements on the QTP are geographically imbalanced, with high concentrations in the eastern and southern regions and sparse distribution in the west and north. This pattern forms a clear destination hierarchy: core zones around Xining, Lhasa, and the Dali-Lijiang cluster account for 21.48% of the area; transition zones cover 52.65%; and marginal zones account for 25.87%.

Figure 2: *Zoning results of tourism elements and tourism activity intensity on the Qinghai-Tibet Plateau*



Source: *Calculated by the authors using tourism POI data (2023) from AutoNavi Maps through Kernel Density Analysis in ArcGIS 10.8*

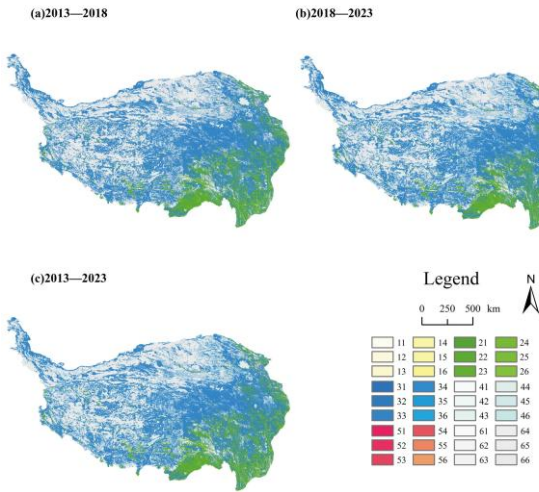
Tourism expansion reshapes ecological space unevenly because it follows accessibility and resources. Catering, lodging, and shopping facilities form a "linear-cluster" pattern along the Qinghai–Tibet Railway and national highways, creating hotspots of human activity in a vast sparse

landscape. Ecological pressure is therefore concentrated at development poles.

Land-use change under tourism expansion

From 2013 to 2023, tourism expansion became a major driver of land-use transformation. Construction land increased by 51.59%, accelerating after 2018 as the dynamic degree rose from 3.34% to 5.98%, mainly by occupying cultivated land (-1.24%), grassland (-0.15%), and unutilized land.

Figure 3: *Land-use conversion among different land-use types on the Qinghai-Tibet Plateau over the past decade*



Source: *Compiled by the authors using ArcGIS 10.8 based on land use remote sensing monitoring data from the Resource and Environmental Science Data Platform (n.d.).*

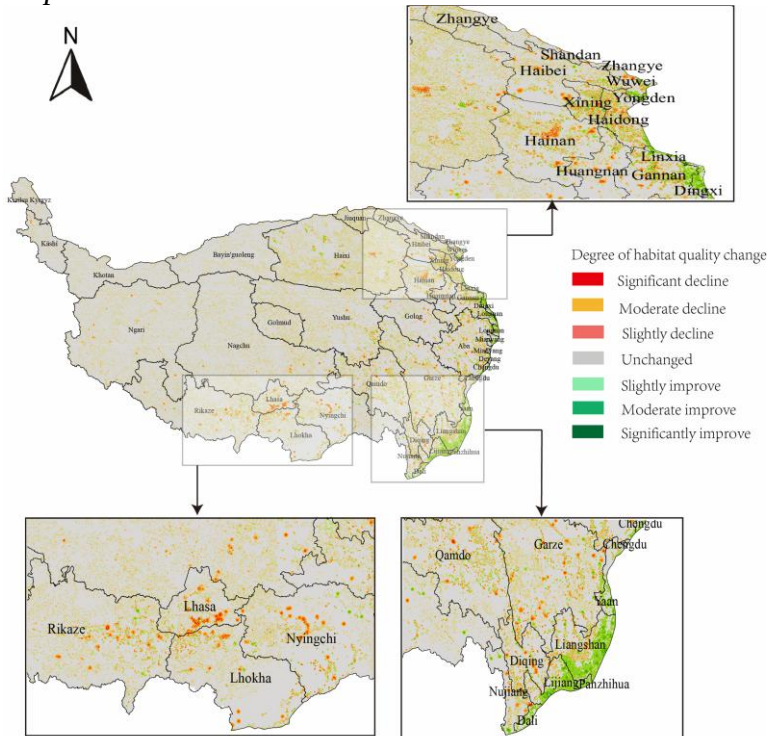
This restructuring reflects tourism's "material embedding" in destination space. As Lhasa and Xining move toward "rapid development," roads, accommodation, and retail services reshape the landscape. When infrastructure growth outpaces regulation, physical development encroaches on ecological spaces.

Habitat quality change and localized degradation

The QTP habitat-quality index rose slightly from 0.598 to 0.603, suggesting regional stability, but outcomes were polarized. High-grade

habitats remained stable in protected zones (66.80% of the area), while degradation intensified around cities and tourism nodes east of the Zhangye-Shigatse line, especially Lhasa, Xining, and Diqing.

Figure 4: Degree of habitat quality change on the Qinghai-Tibet Plateau over the past decade.



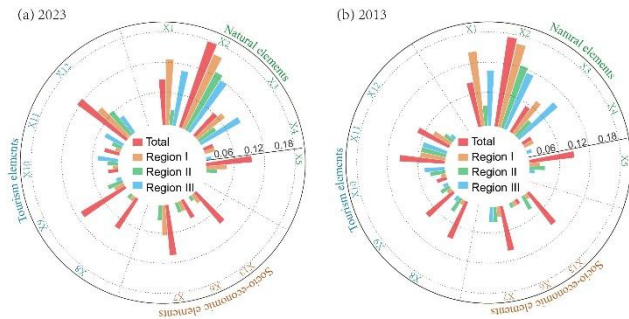
Source: Derived from the InVEST Habitat Quality Model using land use remote sensing monitoring data from the Resource and Environmental Science Data Platform (n.d.).

This pattern shows concentrated socio-ecological reorganization rather than generalized collapse. Degradation appears where tourism-led urbanization is most aggressive, confirming that high-altitude ecosystems may maintain regional quality yet still exceed recovery capacity in localized "material hotspots."

Changing role of natural and human drivers

GeoDetector shows that natural conditions still dominate habitat-quality variation, while tourism and socioeconomic drivers are gaining influence.

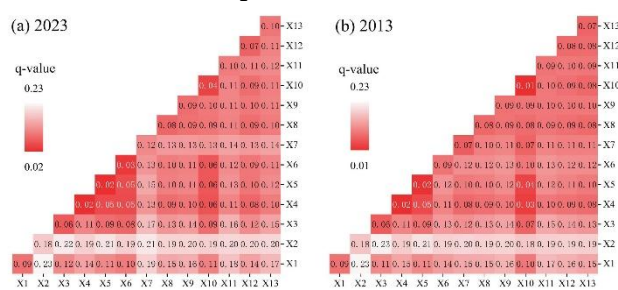
Figure 5: *Single-factor detection results of habitat quality drivers on the Qinghai-Tibet Plateau under different tourism activity intensities over the past decade.*



Source: *Calculated by the authors using GeoDetector based on integrated datasets from the National Tibetan Plateau Science Data Center (n.d.).*

In 2023, annual precipitation had the highest explanatory power ($q = 0.182$), followed by GDP (0.117), tourist attraction density (0.102), and recreational density (0.095). Natural factors remained fundamental, while GDP, roads, and tourism variables became stronger in core and transition zones.

Figure 6: *Interactive detection results of habitat quality drivers on the Qinghai-Tibet Plateau over the past decade*



Source: *Compiled by the authors using GeoDetector based on integrated datasets from the National Tibetan Plateau Science Data Center (n.d.).*

Interaction results confirm this shift. In 2023, the strongest pairs were annual precipitation $\times$ annual temperature (0.23), annual precipitation $\times$ elevation (0.21), annual precipitation $\times$ GDP (0.20), and annual precipitation $\times$ tourist attraction density (0.20). Habitat differentiation is increasingly shaped by climate, topography, economy, and tourism together.

In this co-driven system, governance is no longer limited to managing external impacts on a fixed natural background. Natural conditions set constraints, but socio-economic and tourism choices increasingly shape habitat quality. Governance must shift toward active spatial regulation of human drivers.

Management implications

The QTP findings show that sustainable destination transformation requires proactive, differentiated governance rather than passive restriction. Fragile high-altitude regions need tourism roles assigned by ecological capacity and development pressure, so tourism intensity matches ecological sensitivity.

In core tourism zones, where visitors and facilities concentrate, management should emphasize capacity control and restoration. Ecological red lines and land-use controls must limit construction-land expansion. Time-slot reservations, congestion control, and visitor diversion can reduce localized stress, while ecological compensation and restoration repair degraded habitats.

Transition zones are key preventive spaces because they absorb spillover from cores and cover more than half of the plateau. Management should set ecological thresholds and compact service layouts so moderate growth stays within capacity. Green infrastructure and approval systems should reflect habitat sensitivity and guide development away from critical ecological nodes.

In marginal zones, where natural factors dominate and fragility is extreme, strict protection should prevail. These areas should be ecological reserves, not mass-tourism frontiers. Large-scale infrastructure must be prevented, and tourism limited to low-impact ecotourism, scientific education, and community-based eco-experiences that protect landscape integrity.

This tiered model helps fragile plateau destinations shift from growth-oriented development to a socio-ecological system where ecological integrity underpins destination quality.

Conclusion

This study examined QTP reorganization from 2013 to 2023 through sustainable destination transformation. Tourism expansion selectively embeds material development in nodes and corridors rather than spreading uniformly. Although regional habitat quality remains stable, the 51.59% increase in construction land and localized degradation near major hubs indicate a socio-ecological co-driven transition.

Fragile destinations achieve sustainability neither by restricting growth everywhere nor by expanding without limits. The key is matching tourism intensity with ecological capacity. Capacity control in core zones, preventive regulation in transition zones, and strict protection in marginal zones can balance tourism development and ecological integrity.

Ecological protection is part of destination quality, not an external constraint on growth. For high-altitude destinations such as the QTP, tourism success depends on preserving landscapes and environmental functions. Future research should combine high-resolution monitoring with scenario simulations to refine governance under rising tourism demand.

References

1. Belej, M. (2021). Analysis of spatial distribution of touristic accommodation in Poland with the kernel density estimation of POIs. *Acta Scientiarum Polonorum Administratio Locorum*, 20(3), 159–171. <https://doi.org/10.31648/aspal.6818>
2. Cao, H., Wu, Z., & Zheng, W. (2024). Impact of touristification and landscape pattern on habitat quality in the Longji Rice Terrace Ecosystem, southern China, based on geographically weighted regression models. *Ecological Indicators*, 166, 112259. <https://doi.org/10.1016/j.ecolind.2024.112259>
3. Hall, L. S., Krausman, P. R., & Morrison, M. L. (1997). The habitat concept and a plea for standard terminology. *Wildlife Society Bulletin*, 25, 173–182.
4. Jiang, F. R., Liu, C. H., Zhao, J. N., Jiang, B. D., & Fan, F. Y. (2024). Habitat quality assessment on the Qinghai-Tibet Plateau across vegetation

ecoregions using InVEST and Geodetector models. *Frontiers in Earth Science*, 12, 1432434. <https://doi.org/10.3389/feart.2024.1432434>

5. Lin, Y., Jin, Y., Lin, M., Wen, L., Lai, Q., Zhang, F., Ge, Y., & Li, B. (2024). Exploring the spatial and temporal evolution of landscape ecological risks under tourism disturbance: A case study of the Min River Basin, China. *Ecological Indicators*, 166, 112412. <https://doi.org/10.1016/j.ecolind.2024.112412>

6. National Tibetan Plateau Science Data Center. (n.d.). *Meteorological, GDP, and boundary data of the Qinghai–Tibet Plateau*. Retrieved May 15, 2024, from <https://data.tpdc.ac.cn/>.

7. Nie, Y., Zhang, X., Yang, Y., Liu, Z., He, C., Chen, X., & Lu, T. (2023). Assessing the impacts of historical and future land-use/cover change on habitat quality in the urbanizing Lhasa River Basin on the Tibetan Plateau. *Ecological Indicators*, 148, 110147. <https://doi.org/10.1016/j.ecolind.2023.110147>

8. OpenStreetMap Contributors. (n.d.). OpenStreetMap spatial road information. Retrieved May 15, 2024, from <https://www.openstreetmap.org/>

9. OpenTopography. (n.d.). Copernicus Global Digital Elevation Model. Retrieved May 15, 2024, from <https://portal.opentopography.org/>

10. Resource and Environmental Science Data Platform. (n.d.). Land use remote sensing monitoring results. Retrieved May 15, 2024 from <http://www.resdc.cn>.