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A Bibliometric Analysis of Habitat Quality Studies in Ecologically Vulnerable Areas of China

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Abstract

Research on habitat quality in ecologically vulnerable areas has gained attention due to mountain urbanization and climate change. However, the absence of comprehensive reviews limits a systematic understanding of habitat quality. This study investigates habitat quality research in ecologically vulnerable regions of China, drawing data from Web of Science and Scopus. Using CiteSpace software analyzes trends in publication volume, geographic distribution, journal outlets, research disciplines, and keyword co-occurrence. The findings identify two distinct research phases: an initial exploratory stage and a period of steady growth, with the Loess Plateau emerging as a primary focal region. Key journals, such as Ecological Indicators and Acta Ecologica Sinica, dominate the field, reflecting contributions from disciplines including environmental science and ecology. Research hotspots center on trade-offs between habitat quality and ecosystem services, driving factors of change, landscape pattern optimization, and simulation techniques. Future research should prioritize addressing the spatial heterogeneity of vulnerable regions, advancing methodological approaches, and enhancing uncertainty analyses in model parameterization. This study provides a critical foundation for addressing key scientific challenges and guiding future research, with implications for ecological security and sustainable development.

Keywords

Ecologically Vulnerable Areas, Habitat Quality, Knowledge Mapping, Bibliometrics, Ecological Security, Sustainable Development

1. Introduction

China's ecologically vulnerable areas are diverse and face significant threats of degradation due to instability and limited recovery capacity (Liu et al., 2015; Chen et al., 2021a). Habitat quality, which indicates the ecosystem's ability to support organisms, is crucial for assessing biodiversity and ecological security (Hall et al., 1997; Song et al., 2021). Recent challenges like biodiversity loss, rocky desertification, and soil erosion have greatly impacted habitat quality and local economic development (Ren et al., 2022; Yuan et al., 2020; Yang, 2021). In the context of rapid urbanization and increasing habitat fragmentation in China's ecologically vulnerable areas (Duan et al., 2024), gaining a comprehensive understanding of the research progress on habitat quality in these regions is essential for promoting regional ecosystem health, establishing ecological security frameworks, and ensuring national ecological security (Wang et al., 2019).

Previous studies on habitat quality in ecologically vulnerable areas analyzed the alignment between organisms' survival requirements and their ecosystems (Liu et al., 2019). These papers relied on field surveys to identify suitable conditions, such as water sources, topography, and human disturbances. Then an evaluation indicator system was developed based on these survival needs for comprehensive analysis (Wang et al., 2015b; Liu et al., 2013). This approach faced challenges in establishing standardized evaluation criteria and the significant time and labor required for sampling complicated long-term data collection (Wu et al., 2015). Recent advancements in 3S technology (GIS, RS, and GPS) have allowed researchers to use models such as MaxEnt (Liu et al., 2013; Wu et al., 2018), InVEST (Liu et al., 2019; Wu et al., 2015), and SolVES (Brown & Brabyn, 2012) for habitat quality evaluation. Hotspot research areas include the Loess Plateau area, Arid desert area, Karst area and the Tibetan Plateau area (Wang et al., 2019; Xue et al., 2022; Wu et al., 2022; Hou et al., 2017; Wei et al., 2022). However, ecologically vulnerable areas have diverse natural conditions, leading to varying habitat quality assessment standards. Limited studies summarizing this research restrict the identification of key themes and the exploration of existing issues, hindering the development of new ideas for future research.

Bibliometrics uses mathematical and statistical methods to quantitatively describe and predict trends in disciplinary development. It helps synthesize scientific knowledge, identify research hotspots, and explore various fields (Liu et al., 2019). The bibliometric tool CiteSpace (Chen et al., 2012) extracts key information from extensive literature and visually presents research hotspots and emerging trends through co-occurrence networks. Recently, CiteSpace has been applied to analyze research in sustainable livelihoods (Zhang et al., 2018), debris flow management (Zhao et al., 2019), and ecological vulnerability (Tian et al., 2012). This study uses Web of Science and Scopus to capture trends in habitat quality research for China's ecologically vulnerable areas. CiteSpace analyzes the geographical distribution, journals, disciplines, and keywords, revealing research hotspots and development trends while providing recommendations for future research.

2. Methods

This study used the Web of Science (WOS, https://webofscience.clarivate.cn/) and

Scopus (https://www-scopuscomuitm.sjlib.cn/) databases for literature retrieval. The WOS search used the query TS = "habitat quality" AND ALL = China, restricting results to "Article" and "Review Article." In Scopus, the query TITLE-ABS-KEY ("habitat quality") AND ALL (China) was applied. Until November 2023, 3232 relevant documents were retrieved, covering 2006 to 2023. This study focuses on ecologically vulnerable areas in China, such as the Northern wind-sand area, Tibetan Plateau area, Arid deserts area, Loess Plateau area and Karst area (Wang et al., 2019). The results were filtered and processed for deduplication, resulting in 317 documents selected for analysis.

The data analysis section summarizes the publication volume of selected studies to clarify the distribution across ecologically vulnerable areas. Descriptive statistics are conducted on the journals, using impact factors from Journal Citation Reports (https://jcr.clarivate.com/). We also use CiteSpace to visualize disciplines and keywords and analyze research methods and model parameters in habitat quality studies.

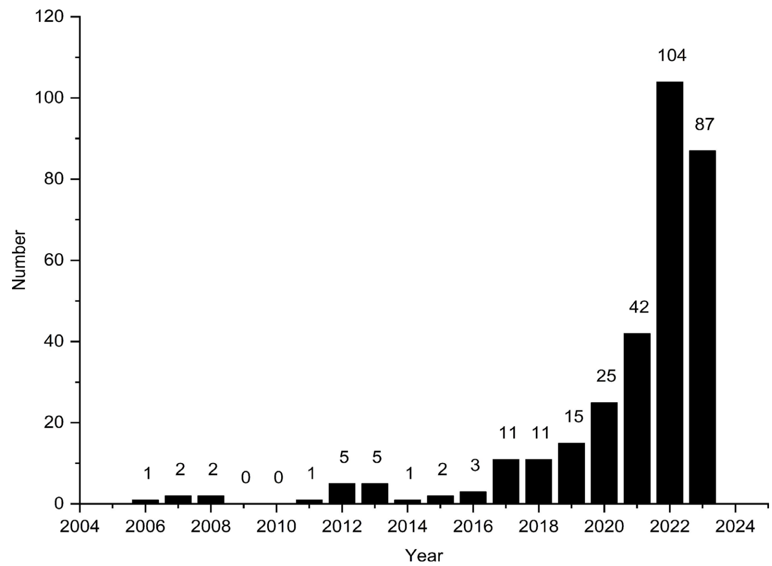

Figure 1. Number of articles published on habitat quality between 2006 and 2023.

3. Results and Discussion

3.1. Characteristics of Publication

Figure 1 indicates a significant growth trend in habitat quality research publications in ecologically vulnerable areas from 2006 to 2023, divided into two phases: initiation (2006-2016) and steady growth (2017-2023). During the initiation phase, annual publications did not exceed five articles, focusing on habitat condition analysis for specific species, predominantly based on field investigations. Publication volume during this period was constrained by data availability. Since 2017, publications have surged, aided by advancements in 3S technology and increased ecological conservation efforts in China, peaking at 104 articles in 2022.

Figure 2 shows the geographical distribution of ecologically vulnerable areas in

China and the proportion of publications on habitat quality in different ecologically vulnerable regions. According to previous studies, these areas can be classified into five major regions: Loess Plateau area, Northern wind-sand area, Arid desert area, Karst area, and Tibet Plateau area (Wang et al., 2019). There are significant differences in the natural environments between these ecologically vulnerable areas. For instance, Loess Plateau area is characterized by extensive Quaternary loess deposits, loose soil structure, and fragmented terrain, with severe soil erosion and strong human activity interference, making it highly vulnerable to geological hazards (Li et al., 2019; Lan et al., 2021). Northern wind-sand area is primarily influenced by wind erosion, exhibiting desertification and severe land degradation (Liu et al., 2008; Wang et al., 2015a). Arid desert area faces water scarcity, sparse vegetation, grassland degradation, and prominent problems of desertification and salinization (Zheng, 2007). Karst area has shallow and infertile soil layers, frequent geological disasters such as landslides and debris flows, and severe soil erosion (Bai et al., 2023; Ma & Zhang, 2018). Tibet Plateau area, under the influence of climate change and human activities, has experienced significant glacier retreat, aggravated soil erosion, and a severe threat to biodiversity (Sun et al., 2012).

Loess Plateau area leads in publication share at 41%, due to significant ecological changes from urbanization and projects like returning farmland to forests. Its habitat conditions impact the ecological security of the Yellow River, attracting research attention. Karst area follows with 22%, as China has the largest distribution of Karst landscapes, making it a key focus in ecological studies. Arid desert area and Tibet Plateau area account for 16% and 13%, respectively, while the Northern wind-sand area has the smallest share at 8%.

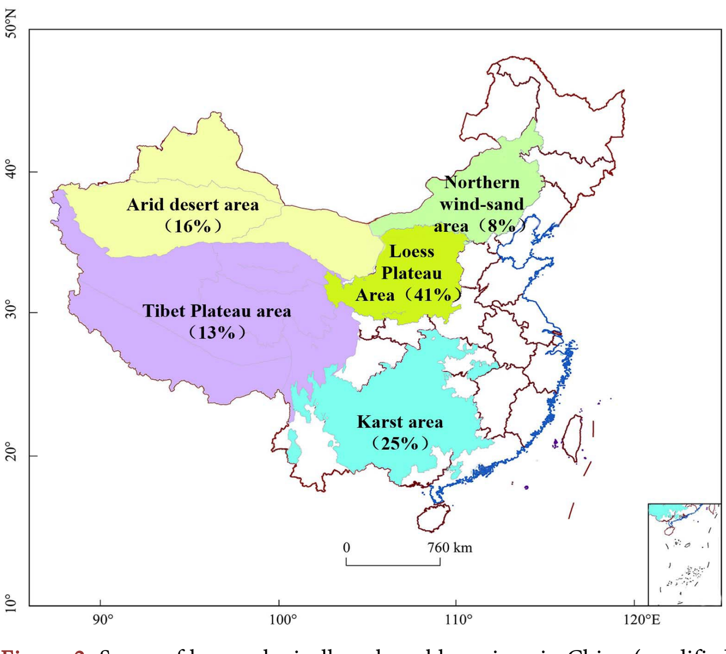

Figure 2. Scope of key ecologically vulnerable regions in China (modified from Wang et al., 2019).

3.2. Analysis of Journals

Research on habitat quality in ecologically vulnerable areas of China was analyzed, revealing 78 publications across English and Chinese journals. The top five journals accounted for 45% of total publications (Figure 3). Ecological Indicators (Impact Factor: 7.0) published the most papers (37), followed by Sustainability (Impact Factor: 3.3, 13 papers) and the International Journal of Environmental Research and Public Health (Impact Factor: 4.6, 10 papers). Among Chinese journals, Acta Ecologica Sinica (Impact Factor: 6.4) published 31 articles, focusing on fundamental theory and innovative applied research in ecology and its sub-disciplines. The second-ranking journals included the Chinese Journal of Applied Ecology, Chinese Journal of Ecology, Arid Zone Geography, and Arid Zone Research. Overall, habitat quality research is primarily published in ecology-related journals.

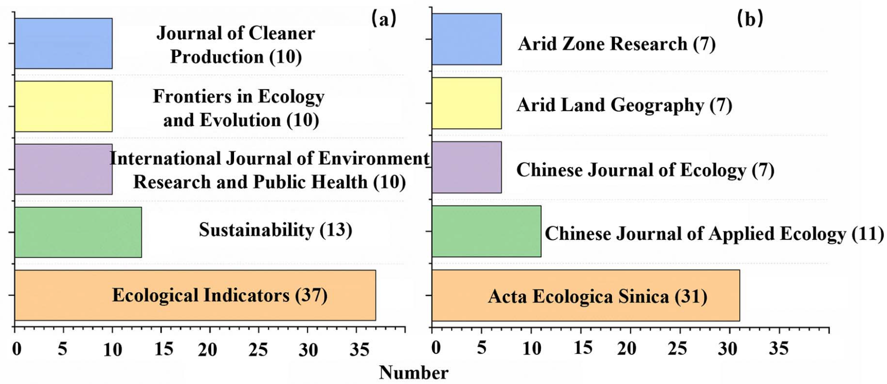

Figure 3. The top 5 English and Chinese core journals.

3.3. Subject Categories Analysis

Figure 4 illustrates the subject areas in habitat quality research in ecologically vulnerable areas, classified by WOS subject categories. Node size indicates frequency, and color denotes the time of appearance; the purple outer ring indicates stronger centrality, meaning these subjects frequently co-occur with others. The most common subject is "Environmental Sciences" followed by "Biodiversity Conservation" and "Ecology". This suggests that the disciplines most strongly associated with habitat quality. Some studies also include geography, remote sensing, and meteorology, including "Geography, Physical" "Geosciences, Multidisciplinary" "Remote Sensing" and "Meteorology & Atmospheric Sciences".

3.4. Keyword Co-Occurrence

The keywords frequently identified in research on habitat quality in ecologically vulnerable areas were analyzed, with those appearing over 20 times listed in Table 1. The most common keyword is "habitat quality" (148 occurrences), the central theme of this paper. The keyword with the highest centrality is "biodiversity" (0.52), closely linked to habitat quality and various research themes. Analyzing

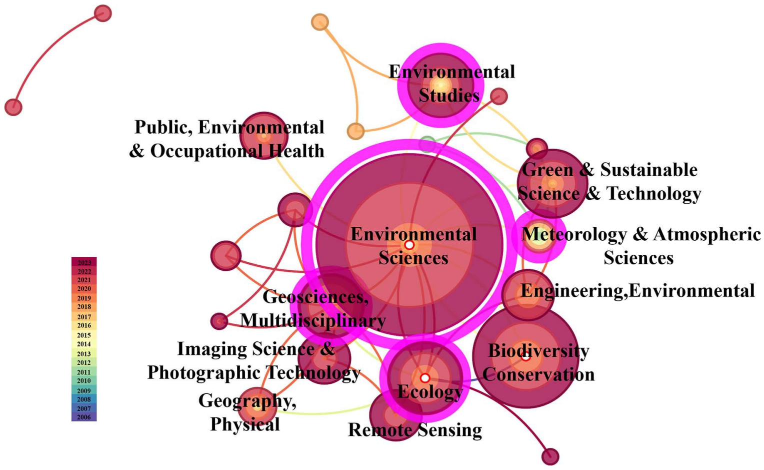

Figure 4. The top 5 English and Chinese core journals.

these keywords reveals insights into the research context (e.g., urbanization, climate change), research content (e.g., impact trade-offs, dynamics), methods (e.g., InVEST model), data sources (e.g., land use), and objectives (e.g., biodiversity conservation).

Table 1. Keywords of high frequency in habitat quality research.

Frequency	Centrality	Keywords	Frequency	Centrality	Keywords
148	0.12	habitat quality	37	0.05	trade offs
144	0.13	ecosystem services	34	0.03	loess plateau
98	0.24	China	30	0.08	ecosystem
79	0.04	InVEST model	28	0.05	urbanization
74	0.52	biodiversity	26	0.09	Environmental protection
63	0.1	land use	24	0.05	climate change
59	0.1	land use change	21	0.07	ecological restoration
48	0.03	impact	21	0.02	synergy
42	0.09	conservation	20	0.02	dynamics
38	0.04	model	20	0.02	simulation

Figure 5 shows a co-occurrence map of keywords divided into five groups: #1 Habitat Quality and Ecosystem Services, #2 Drivers of Habitat Quality, #3 Habitat Quality and Landscape Patterns, and #4 Modeling and Prediction of Habitat Quality.

"#1" reflects research on ecosystem services, highlighting keywords such as "land use change" "ecosystem services" and "biodiversity". Land use changes impact the composition and structure of ecosystems, which subsequently affect material and energy flows within habitat patches. These changes facilitate the assessment of habitat quality at a regional scale, making land use change a common focus in habitat quality research (Zhao et al., 2022; Foley et al., 2005). Habitat quality is generally viewed as a reflection of regional biodiversity and is often analyzed in relation to trade-offs and synergies with other ecosystem services, such as carbon storage and water yield (Teng et al., 2022). Trade-offs occur when improving one ecosystem service reduces another, while synergy indicates that enhancing one service can benefit another. Research on the trade-offs and synergies between habitat quality and other ecosystem services aids managers in balancing multiple services to maximize overall benefits. Research on the Loess Plateau reveals a trade-off between habitat quality and water yield, while a synergy exists between habitat quality and Net Primary Production (NPP) (Liu et al., 2019; Yan et al., 2021). This suggests that improving habitat quality can increase NPP but also raises water demand, thereby reducing water yield.

"#2" analyzes the driving factors affecting habitat quality, highlighting keywords like "driving factors," "geographically weighted regression," "geodetector," and "structural equation model" which indicate the main research methods. Habitat quality varies spatially due to the combined effects of natural, human, and social factors (Zhao et al., 2022; Chen et al., 2021b). While factors affecting habitat quality vary across research scales, comparative studies are limited. Natural conditions largely determine habitat quality distribution, with human activities modifying it. Land use, landscape dynamics, climate change, and macro-environmental policies all influence habitat quality (Chen et al., 2021b; Chen et al., 2022; Hua et al., 2021). The interaction mechanisms between natural and human factors need further investigation.

"#3" reflects research on habitat quality and landscape patterns, emphasizing "ecological security pattern," "ecological corridor," and "circuit theory." Human activities have significantly altered vulnerable landscapes, making ecological security patterns essential for maintaining eco-economic balance. The framework using ecological sources, nodes, and corridors is widely applied (Forman, 1995; Yu, 1999; Peng et al., 2017). Habitat quality, reflecting biodiversity, is crucial for selecting ecological sources and assessing corridor accessibility. High-quality habitats, rich in biodiversity, facilitate energy and information flows, while low-quality habitats hinder them (Gao et al., 2022). Ecological corridors are vital for exchanging materials, energy, and information (Gou et al., 2022), and well-connected corridors support biodiversity conservation and ecosystem stability.

"#4" emphasizes terms like "scenario simulation," "PLUS model," and "climate change," reflecting research on habitat quality prediction. Accurately forecasting habitat quality trends is vital for preventing degradation and formulating ecological security strategies amid climate change (Chu et al., 2018). Models such as CA-Markov and PLUS effectively simulate the nonlinear dynamics of land use change, which significantly impacts habitat quality (Ding et al., 2021). For instance, Wu et al. used these models to predict habitat quality changes in the Hubei section of the Three Gorges Reservoir Region (Wu et al., 2022). Another study assessed habitat quality in the Qilian Mountain Nature Reserve using the PLUS and InVEST models (Zhang et al., 2024). Both studies found that habitat quality was higher under ecological protection scenarios than under natural development scenarios, highlighting the need for ecological conservation. Simulating future habitat quality can aid land managers in creating sustainable land-use policies.

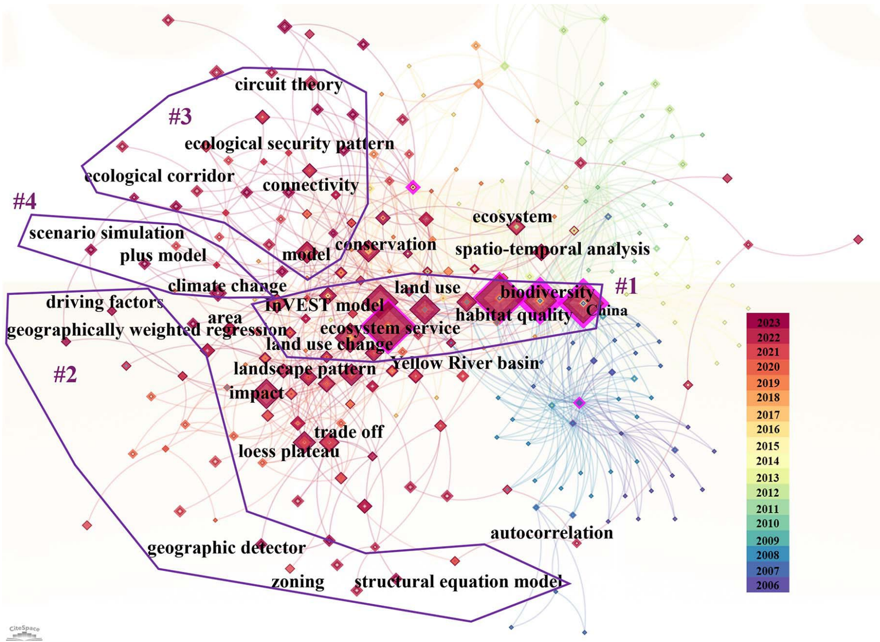

Figure 5. Keyword co-occurrence network. (Citespace settings: Node Types: Keywords; Selection Criteria: k = 15; Pruning: Pathfinder Pruning sliced networks, others: default).

3.5. Habitat Quality Evaluation Model

This study includes a statistical analysis of research methods used in studies, as shown in Figure 6(a). In China's ecologically vulnerable areas, six methods are commonly employed: InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model, Indicator-based evaluation, MaxEnt (Maximum Entropy) model, Field surveys, HSI (Habitat Suitability Index) model, and SolVES (Social Values for Ecosystem Services) model. The InVEST model is the most prevalent, used in 90.2% of studies, which utilizes land-use data to assign habitat suitability values to different land types and incorporates habitat threat sources to assess habitat quality (Ren et al., 2022). Its straightforward data requirements and ease of use make it a popular choice for evaluating habitat quality in these areas. The indicator-based evaluation method is the second most common approach (4.4%), involving the selection of indicators based on ecological requirements and assigning weights to calculate habitat quality. Recent advancements in geospatial data in China have facilitated its regional application, but its lower usage compared to the InVEST model is due to susceptibility to subjective bias in the weighting process. The Indicator Evaluation Method is flexible, user-friendly, and capable of selecting appropriate ecological indicators based on the research subject, making it well-suited for regional-scale habitat quality assessments. However, this method is highly susceptible to subjective influences, as improper weighting can result in biased evaluation outcomes. Additionally, it tends to oversimplify the complexity of ecosystems and struggles to quantify intricate ecological relationships. The MaxEnt Model, which is grounded in maximum entropy theory, effectively addresses situations with incomplete data and is adept at processing high-dimensional environmental data and complex spatial relationships. (Liu et al., 2013). However, its accuracy is contingent upon the quality of the input data, and it has limitations in addressing the temporal dynamics of habitats and ecological processes. Furthermore, the MaxEnt Model lacks interpretability, which may pose challenges for non-experts attempting to understand and apply it. In summary, the Indicator Evaluation Method is suitable for rapid assessments but may exhibit significant subjectivity, while the MaxEnt Model is better equipped for managing complex spatial data and sparse datasets, although it may not be as precise as other methods in certain ecological studies. Other methods, including field surveys (1.5%), the HSI model (0.6%), and the SolVES model (0.5%), are less common.

Habitat suitability, a key parameter in the InVEST model, ranges from 0 to 1 and indicates species survival capacity in various land-use types. Statistical analysis of mean habitat suitability values, shown in Figure 6(b), reveals that forest has the highest suitability, exceeding 0.8, followed by grassland and water body with values above 0.7. Cropland ranges from 0.3 to 0.4, while unused land and urban areas fall below 0.1. This subjective parameter's accuracy depends on the researcher's understanding of the area, but many studies rely on previous research without considering local conditions, limiting parameter customization.

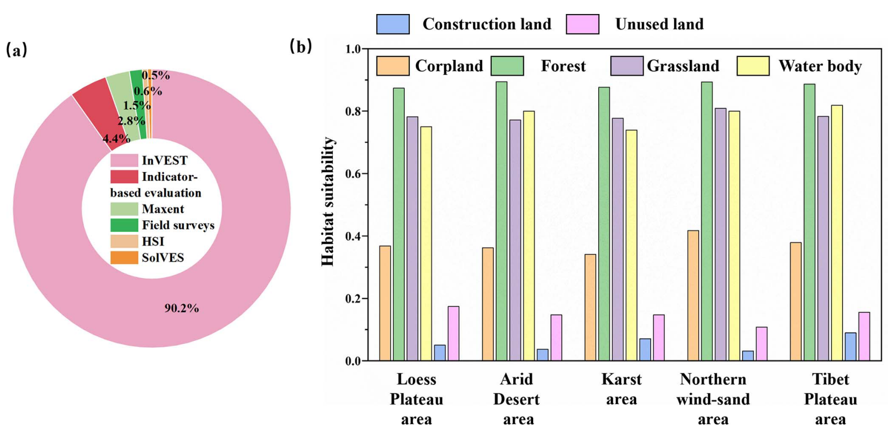

Figure 6. Statistical chart of habitat quality research methods and parameter settings (a) Research methods (b) Parameter settings.

3.6. Challenges and Future Work

Identifying the spatiotemporal evolution of habitat quality in ecologically vulnerable areas is essential for regulating ecosystem functions and optimizing ecological security patterns (Wang et al., 2022). Despite progress in this research, challenges in habitat quality assessment remain.

1) Habitat quality assessment largely relies on land-use data, often overlooking key factors that lead to degradation. This can result in uniform evaluations across ecologically vulnerable areas. While high vegetation cover is typically associated

with better habitat quality, this is not always the case. In areas like the Loess Plateau and arid deserts, expanding forest cover can strain limited water resources, threatening their sustainability (Feng et al., 2016). Studies show that large-scale afforestation in the Loess Plateau increases regional water consumption and that vegetation in arid areas has deeper root systems than in humid regions, worsening groundwater drought (Han et al., 2020). This suggests that classifying forestland as high-value habitat, as in **Figure 5(b)**, often overlooks key ecological challenges. Future research on habitat quality in vulnerable areas should consider local environmental characteristics and select relevant ecological factors. It is also essential to evaluate the differing impacts of the same land-use type on habitat quality across various vulnerable areas for a more accurate assessment of changes.

2) Habitat quality assessment methods are relatively limited and often lack uncertainty analysis for model parameters. Most studies currently use the InVEST model for regional evaluations. While it aids in assessments, diverse research methods offer unique insights, and reliance on a single model can hinder a comprehensive understanding of habitat quality (Shi et al., 2023). Future research should use diverse methods, such as physical models to simulate ecological processes and clarify habitat quality dynamics. Comparative analyses, validated with field data, will help identify the most accurate evaluation results. Habitat quality assessment models often face challenges due to subjective parameter settings based on prior studies rather than tailored to specific areas. Future research could reduce this subjectivity by integrating field data, combining models, and using machine learning techniques.

Habitat quality is a key factor determining the vulnerability, resilience, and recovery capacity of ecosystems. High-quality habitats typically feature rich biodiversity and well-functioning ecological processes, which not only reduce ecosystem vulnerability but also enhance its ability to adapt to and recover from external disturbances. Good habitat quality enables ecosystems to exhibit greater resilience, maintaining their structure and functions while quickly restoring ecological services when faced with climate change, pollution, or human activities. In contrast, low-quality habitats can lead to species loss and degradation of ecological functions, thereby increasing vulnerability and reducing the system's self-recovery capacity. Therefore, improving habitat quality is a critical objective for ecological restoration. By enhancing habitat conditions, promoting biodiversity, and restoring ecological processes, the recovery and sustainability of ecosystems can be effectively supported. In recent decades, China has placed high importance on ecological policies and implemented a series of ecological engineering projects, which play a crucial role in improving habitat quality. Ecological engineering measures such as vegetation restoration, water management, and wetland rehabilitation directly improve habitat quality, enhancing ecosystem resilience and recovery capacity. The synergistic effect of policies and ecological engineering, through policy guidance, financial support, and the implementation of effective ecological restoration measures, promotes the comprehensive improvement of habitat quality, facilitates the sustainable management of ecosystems, and protects biodiversity. Ultimately, this combination strengthens ecosystem stability and ecological security, laying a solid foundation for achieving sustainable development.

4. Conclusion

This study analyzed 317 papers from 2006 to 2023 in the Web of Science and Scopus databases on habitat quality in China's ecologically vulnerable areas. Using bibliometric methods, it assessed publication trends, geographical distribution, journals, references, and keywords. Results indicate an annual increase in publications, particularly since 2017, with the Loess Plateau receiving the most attention. Related research is published in journals like Ecological Indicators and Acta Ecologica Sinica, focusing on environmental science, ecology, and biodiversity conservation. Despite progress, challenges include reliance on land use data, limited evaluation models, subjective parameters. Future research should integrate ecosystem elements and customize evaluation indicators for specific study areas. Combining field observations with machine learning can reduce subjectivity in model parameters, enhancing understanding of habitat quality and supporting sustainable development in vulnerable areas.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Bai, X. Y., Zhang, S. R., Ran, C. et al. (2023). Ten Problems and Solutions for Restoration of Karst Ecosystem in Southwest China. *Bulletin of Chinese Academy of Sciences, 38,* 1903-1914.

Brown, G., & Brabyn, L. (2012). The Extrapolation of Social Landscape Values to a National Level in New Zealand Using Landscape Character Classification. *Applied Geography, 35,* 84-94. https://doi.org/10.1016/j.apgeog.2012.06.002

Chen, C., Hu, Z., Liu, S., & Tseng, H. (2012). Emerging Trends in Regenerative Medicine: A Scientometric Analysis In*citespace*. *Expert Opinion on Biological Therapy, 12,* 593-608. https://doi.org/10.1517/14712598.2012.674507

Chen, Y., Li, Y. Q., Wang, X. Y. et al. (2021a). Advances in Ecological Stoichiometry in Typically and Ecologically Vulnerable Regions of China. *Acta Ecologica Sinica, 41,* 4213-4225.

Chen, Z., Li, Y., Liu, Y., & Liu, X. (2021b). Does Rural Residential Land Expansion Pattern

Lead to Different Impacts on Eco-Environment? A Case Study of Loess Hilly and Gully Region, China. *Habitat International, 117,* Article ID: 102436. https://doi.org/10.1016/j.habitatint.2021.102436

Chen, Z., Li, Y., Liu, Z., Wang, J., & Liu, X. (2022). Impacts of Different Rural Settlement Expansion Patterns on Eco-Environment and Implications in the Loess Hilly and Gully Region, China. *Frontiers in Environmental Science, 10,* Article 857776. https://doi.org/10.3389/fenvs.2022.857776

Chu, L., Sun, T., Wang, T., Li, Z., & Cai, C. (2018). Evolution and Prediction of Landscape Pattern and Habitat Quality Based on Ca-Markov and Invest Model in Hubei Section of Three Gorges Reservoir Area (TGRA). *Sustainability, 10,* Article 3854. https://doi.org/10.3390/su10113854

Ding, Q., Chen, Y., Bu, L., & Ye, Y. (2021). Multi-scenario Analysis of Habitat Quality in the Yellow River Delta by Coupling FLUS with Invest Model. *International Journal of Environmental Research and Public Health, 18,* Article 2389. https://doi.org/10.3390/ijerph18052389

Duan, P., Chen, W. B., Yang, H. et al. (2024). Influence and Interactions of Habitat Fragmentation Progress on Habitat Quality in Watersheds. *Acta Ecologica Sinica, 44,* 6053-6066.

Feng, X., Fu, B., Piao, S., Wang, S., Ciais, P., Zeng, Z. et al. (2016). Revegetation in China's Loess Plateau Is Approaching Sustainable Water Resource Limits. *Nature Climate Change, 6,* 1019-1022. https://doi.org/10.1038/nclimate3092

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R. et al. (2005). Global Consequences of Land Use. *Science, 309,* 570-574. https://doi.org/10.1126/science.1111772

Forman, R. T. T. (1995). Some General Principles of Landscape and Regional Ecology. *Landscape Ecology, 10,* 133-142. https://doi.org/10.1007/bf00133027

Gao, M., Hu, Y., & Bai, Y. (2022). Construction of Ecological Security Pattern in National Land Space from the Perspective of the Community of Life in Mountain, Water, Forest, Field, Lake and Grass: A Case Study in Guangxi Hechi, China. *Ecological Indicators, 139,* Article ID: 108867. https://doi.org/10.1016/j.ecolind.2022.108867

Gou, M., Li, L., Ouyang, S., Shu, C., Xiao, W., Wang, N. et al. (2022). Integrating Ecosystem Service Trade-Offs and Rocky Desertification into Ecological Security Pattern Construction in the Daning River Basin of Southwest China. *Ecological Indicators, 138,* Article ID: 108845. https://doi.org/10.1016/j.ecolind.2022.108845

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.

Han, Z., Huang, S., Huang, Q., Bai, Q., Leng, G., Wang, H. et al. (2020). Effects of Vegetation Restoration on Groundwater Drought in the Loess Plateau, China. *Journal of Hydrology, 591,* Article ID: 125566. https://doi.org/10.1016/j.jhydrol.2020.125566

Hou, Y., Lü, Y., Chen, W., & Fu, B. (2017). Temporal Variation and Spatial Scale Dependency of Ecosystem Service Interactions: A Case Study on the Central Loess Plateau of China. *Landscape Ecology, 32,* 1201-1217. https://doi.org/10.1007/s10980-017-0497-8

Hua, T., Zhao, W., Cherubini, F., Hu, X., & Pereira, P. (2021). Sensitivity and Future Exposure of Ecosystem Services to Climate Change on the Tibetan Plateau of China. *Landscape Ecology, 36,* 3451-3471. https://doi.org/10.1007/s10980-021-01320-9

Lan, H. X., Peng, J. B., Zhu, Y. B. et al. (2021). Research on Geological and Surfacial Processes and Major Disaster Effects in the Yellow River Basin. *Science China Earth Sciences, 65,* 234-256.

Li, Z. S,. Yang, L., Wang, G. L. et al. (2019). The Management of Soil and Water Conservation in the Loess Plateau of China: Present Situations, Problems, and Counter-Solutions. *Acta Ecologica Sinica, 39,* 7398-7409.

Liu, H. J., Chai, H. X., Cheng, W. M. et al. (2008). A Research of Aeolian Landform in Northern China Based on Remote Sensing Imagery. *Geographical Research, No. 1,* 109-118.

Liu, J., Zou, C., Gao, J., Ma, S., Wang, W., Wu, K. et al. (2015). Location Determination of Ecologically Vulnerable Regions in China. *Biodiversity Science, 23,* 725-732. https://doi.org/10.17520/biods.2015147

Liu, L., Zhang, H., Gao, Y., Zhu, W., Liu, X., & Xu, Q. (2019). Hotspot Identification and Interaction Analyses of the Provisioning of Multiple Ecosystem Services: Case Study of Shaanxi Province, China. *Ecological Indicators, 107,* Article ID: 105566. https://doi.org/10.1016/j.ecolind.2019.105566

Liu, Z. S., Gao, H., Teng, L. W. et al. (2013). Habitat Suitability Assessment of Blue Sheep in Helan Mountain Based on MAXENT Modeling. *Acta Ecologica Sinica, 33,* 7243-7249. https://doi.org/10.5846/stxb201207221041

Ma, Q. H., & Zhang, K. L. (2018). Progresses and Prospects of the Research on Soil Erosion in Karst Area of Southwest China. *Advances in Earth Science, 33,* 1130-1141.

Peng, J., Zhao, H. J., Liu, Y. X. et al. (2017). Research Progress and Prospect on Regional Ecological Security Pattern Construction. *Geographical Research, 36,* 407-419.

Ren, Q., He, C., Huang, Q., Shi, P., Zhang, D., & Güneralp, B. (2022). Impacts of Urban Expansion on Natural Habitats in Global Drylands. *Nature Sustainability, 5,* 869-878. https://doi.org/10.1038/s41893-022-00930-8

Shi, X., Nie, T. Z., Xiong, Q. et al. (2023). Assessment of Carbon Stock and Sequestration of the Mangrove Ecosystems on Hainan Island Based on Invest and Maxent Models. *Journal of Tropical Biology, 14,* 298-306.

Song, Y., Wang, M., Sun, X., & Fan, Z. (2021). Quantitative Assessment of the Habitat Quality Dynamics in Yellow River Basin, China. *Environmental Monitoring and Assessment, 193,* Article No. 614. https://doi.org/10.1007/s10661-021-09404-4

Sun, H. L., Zheng, D., Yao, T. D. et al. (2012). Protection and Construction of the National Ecological Security Shelter Zone on Tibetan Plateau. *Acta Geographica Sinica, 67,* 3-12.

Teng, Y., Zhan, J., Liu, W., Chu, X., Zhang, F., Wang, C. et al. (2022). Spatial Heterogeneity of Ecosystem Services Trade-offs among Ecosystem Service Bundles in an Alpine Mountainous Region: A Case- Study in the Qilian Mountains, Northwest China. *Land Degradation & Development, 33,* 1846-1861. https://doi.org/10.1002/ldr.4266

Tian, Y. P., & Chang, H. (2012). Bibliometric Analysis of Research Progress on Ecological Vulnerability in China. *Acta Geographica Sinica, 67,* 1515-1525.

Wang, B. C., Xu, L. J., Zhu, L. L. et al. (2015a). Analysis of the Results of the Division of Soil and Water Conservation in the Northern Aeolian Sand Area. *Soil and Water Conservation in China, No. 12,* 28-31.

Wang, C., Wu, X., Fu, B. J. et al. (2019). Ecological Restoration in the Key Ecologically Vulnerable Regions: Current Situation and Development Direction. *Acta Ecological Sinica, 39,* 7333-7343.

Wang, J. F., Li, L., Li, Q., Hu, S., & Wang, S. (2022). Monitoring Spatio-Temporal Dynamics and Causes of Habitat Quality in Yellow River Basin from the Perspective of Major Function-Oriented Zone Planning. *Contemporary Problems of Ecology, 15,* 418-431. https://doi.org/10.1134/s1995425522040126

Wang, Q., Fan, Z. P., Li, F. Y. et al. (2015b). River Habitat Quality Assessment, Water

Quality Analysis and Their Response Relation of Puhe River Basin. *Acta Ecologica Sinica, 34,* 516-523.

Wei, Q., Halike, A., Yao, K., Chen, L., & Balati, M. (2022). Construction and Optimization of Ecological Security Pattern in Ebinur Lake Basin Based on MSPA-MCR Models. *Ecological Indicators, 138,* Article ID: 108857. https://doi.org/10.1016/j.ecolind.2022.108857

Wu, J., Luo, J., Zhang, H., Qin, S., & Yu, M. (2022). Projections of Land Use Change and Habitat Quality Assessment by Coupling Climate Change and Development Patterns. *Science of the Total Environment, 847,* Article ID: 157491. https://doi.org/10.1016/j.scitotenv.2022.157491

Wu, X., Dong, S., Liu, S., Liu, Q., Han, Y., Zhang, X. et al. (2018). Identifying Priority Areas for Grassland Endangered Plant Species in the Sanjiangyuan Nature Reserve Based on the Maxent Model. *Biodiversity Science, 26,* 138-148. https://doi.org/10.17520/biods.2017188

Wu, Z. S., Cao, Q. W., Shi, S. Q. et al. (2015). Spatio-Temporal Variability of Habitat Quality in Beijing-Tianjin-Hebei Area Based on Land Use Change. *Chinese Journal of Applied Ecology, 26,* 3457-3466.

Xue, C., Zhang, H., Wu, S., Chen, J., & Chen, X. (2022). Spatial-temporal Evolution of Ecosystem Services and Its Potential Drivers: A Geospatial Perspective from Bairin Left Banner, China. *Ecological Indicators, 137,* Article ID: 108760. https://doi.org/10.1016/j.ecolind.2022.108760

Yan, R., Cai, Y., Li, C., Wang, X., Liu, Q., & Yan, S. (2021). Spatial Interactions among Ecosystem Services and the Identification of Win-Win Areas at the Regional Scale. *Ecological Complexity, 47,* Article ID: 100938. https://doi.org/10.1016/j.ecocom.2021.100938

Yang, Y. (2021). Evolution of Habitat Quality and Association with Land-Use Changes in Mountainous Areas: A Case Study of the Taihang Mountains in Hebei Province, China. *Ecological Indicators, 129,* Article ID: 107967. https://doi.org/10.1016/j.ecolind.2021.107967

Yu, K. J. (1999). Landscape Ecological Security Patterns in Biological Conservation. *Acta Ecologica Sinica, 19,* 10-17.

Yuan, Z. J., Ma, D. F., Nie, X. D. et al. (2020). Progress in Research on Prevention and Control of Soil Erosion under Forest in Red Soil Hilly Region of South China. *Acta Pedologica Sinica, 57,* 12-21.

Zhang, C. J., Fang, Y. P., & Chen, X. J. (2018). Bibliometric Analysis of Sustainable Livelihoods Research in China. *Advances in Earth Science, 33,* 969-982.

Zhang, Y,. Wang, R. H., Liu, C. W. et al. (2024). Simulation and Prediction of Habitat Quality in the Qilian Mountain Nature Reserve. *Journal of Nanjing Forestry University (Natural Sciences Edition), 48,* 135-144.

Zhao, L., Yu, W., Meng, P., Zhang, J., & Zhang, J. (2022). invest Model Analysis of the Impacts of Land Use Change on Landscape Pattern and Habitat Quality in the Xiaolangdi Reservoir Area of the Yellow River Basin, China. *Land Degradation & Development, 33,* 2870-2884. https://doi.org/10.1002/ldr.4361

Zhao, P., Du, J., Wang, D. J. et al. (2019). Visualization Analysis on Debris Flow Control and Prevention Research Based on CiteSpace. *Yangtze River, 50,* 28-34.

Zheng, D. (2007). Issues on Land Degradation and Eco-reconstruction in Northwest Arid Region of China. *Chinese Journal of Nature, No. 1,* 7-11.