

Human-Land System Research in the Yellow River Basin Over the Past 30 Years: Trajectory, Hotspots, and Prospects (Postprint)

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Abstract

The Yellow River Basin constitutes a crucial ecological barrier in China, and its ecological protection and high-quality development represent a major national strategy. Based on data from the CNKI database and employing CiteSpace and Origin software for bibliometric analysis of core journals and leading scholars, this study synthesizes the fundamental status, evolutionary trajectory, research hotspots, and frontier dynamics of human-land system research in the Yellow River Basin over the past 30 years. The results demonstrate: (1) The evaluation of human-land relationships in the Yellow River Basin follows a progressive trajectory of “initial understanding-derivation-deepening-coupling,” with applied research concentrating on “basin production-living-ecological space assessment,” “urban ecosystem and economic development,” “human-land system and territorial spatial development,” and “human-land coordination and high-quality development evaluation.” (2) Research hotspots are structured according to the logic of “system structure-system evaluation-practical application,” shifting from sustainability “status quo” assessment to “forward-looking” investigations of driving factors and operational mechanisms, as well as “backward-looking” studies on high-quality development path selection. Methodologically, the field is transitioning from traditional coupling coordination analysis to three-dimensional visualized spatial analysis, while research data are increasingly integrating traditional data, remote sensing data, and big data. (3) Future research should be optimized and deepened along dimensions including “expanding research domains,” “emphasizing tool development,” “constructing a comprehensive integrated research system,” and “strengthening regional development,” thereby advancing the theoretical depth of human-land system research and providing novel perspectives for the research framework of human-land systems in the Yellow River Basin.

Full Text

Studies of the Human-Land System in the Yellow River Basin over the Past 30 Years: Context, Hotspots, and Prospects

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Abstract

The Yellow River Basin constitutes a critical ecological barrier in China, and its ecological protection and high-quality development represent a major national strategic priority. Based on the CNKI database and employing CiteSpace and Origin software for statistical analysis of core journals and leading scholars, this study synthesizes the fundamental status, evolutionary trajectory, research hotspots, and frontier dynamics of human-land system research in the Yellow River Basin from 1992 to 2022. The findings reveal that: (1) Research on the human-land system in the Yellow River Basin began early but remained at a relatively low level for an extended period; since 2019, the field has entered a new phase characterized by rapid growth in publication volume. The evaluation of human-land relationships has followed a progressive trajectory from “initial understanding” to “derivation,” “deepening,” and ultimately “coupling.” Applied research has concentrated on four key areas: basin-scale “production-living-ecological” space assessment, urban ecosystem and economic development, human-land system and territorial spatial development, and human-land coordination and high-quality development evaluation. (2) Guided by the logical framework of “system structure—system evaluation—practical application,” research hotspots have shifted from sustainable “status quo” assessments to “forward-looking” investigations of driving factors and mechanisms, as well as “backward-looking” studies on pathways for high-quality development. Methodologically, the field has transitioned from traditional coupling coordination analysis to three-dimensional visual spatial analysis, while data sources have increasingly integrated traditional statistics, remote sensing, and big data. (3) Future research should optimize and deepen investigations by “extending research domains,” “emphasizing tool development,” “constructing comprehensive integrated research systems,” and “strengthening regional development,” thereby advancing the theoretical depth of human-land system studies and providing new perspectives for the research framework in the Yellow River Basin.

Keywords: Yellow River Basin; human-land system; research progress; CiteSpace

1. Data and Methods

1.1 Data Sources The China National Knowledge Infrastructure (CNKI) database served as the primary data source. The search was limited to source journals, core journals, and CSSCI journals, using the thematic terms “Yellow River Basin” or “Yellow River” combined sequentially with “human-land system,” “ecological protection,” “resource geography,” “environmental geography,” “regional and urban-rural planning,” “historical geography,” and “sustainable development.” The literature search covered the period from 1992 to 2022 and was conducted on December 31, 2022, yielding 1,237 documents (excluding conference information, discipline news, academic debates, book reviews, and announcements).

1.2 Research Methods The analysis proceeded in two stages. First, basic information including annual publication volume, core authors, and core journals was statistically analyzed to summarize the fundamental status of human-land system research in the Yellow River Basin. Second, CiteSpace visualization software was employed to analyze research progress and trends. The analysis utilized the pathfinder function for pruning optimization to enhance network clarity.

2. Bibliometric Analysis and Evolutionary Context

2.1 Publication Trends The annual distribution of research literature reveals that domestic studies on the human-land system in the Yellow River Basin began early but remained at a low level for an extended period. From 1992 to 2018, cumulative publications totaled 573 articles, with annual output fluctuating steadily. The year 2019 marked a watershed moment, after which research entered a new stage of rapid growth, indicating heightened scholarly attention and establishing the topic as an academic hotspot.

2.2 Core Journals CiteSpace analysis identified core journals in the field [Figure 2: see original paper]. Engineering and technology journals (*People’s Yellow River*, *Environmental Protection*), economics and management journals (*Ecological Economy*, *Resources Science*, *Regional Economic Review*), and resource-focused journals (*Natural Resources*, *China Population*, *Resources and Environment*, *Water Resources Protection*) collectively accounted for 57.25% of total publications, forming the primary publication outlets. Geography journals (*Economic Geography*, *Arid Land Geography*, *Acta Geographica Sinica*) and social science journals (*China Population Science*, *Ningxia Social Sciences*, *Qinghai Social Sciences*, *Shandong Social Sciences*) represented 7.32% and 4.41% respectively, while comprehensive journals (*Chinese Academy of Sciences Journal*, university journals) comprised 3.52%. This distribution demonstrates the broad interdisciplinary scope and high societal relevance of human-land system research in the Yellow River Basin.

2.3 Core Authors Author co-occurrence analysis via CiteSpace identified Ren Baoping as the most prolific author with 21 publications. According to Price's law, the core author threshold ($Ma = 0.749 \times \sqrt{N}$, where N represents the maximum publication count) was calculated as 3.43, establishing four publications as the threshold for core authorship. Statistical analysis identified 23 core authors, with Ren Baoping, Zuo Qiting, Miao Changhong, Fu Bojie, and He Aiping ranking as the top five contributors. Their research spans human-land system connotations, coupling mechanisms, urban agglomerations, and sustainable development, indicating extensive influence and widespread societal concern

2.4 Evolutionary Stages Based on an analysis of keyword timeline patterns in relation to development status and national policy formulation [Figure 3: see original paper], the evolution of human-land system research in the Yellow River Basin can be divided into four distinct stages:

Stage 1: Initial Understanding (1992–1999)

This stage focused on keywords such as “Yellow River Basin,” “water resources,” “lower Yellow River,” “Hexi Corridor,” “Qilian Mountains,” “soil and water conservation,” and “high-efficiency water saving.” Research centered on watershed ecological governance, including efficient water resource utilization, river cutoff, sediment management, and water pollution control, as well as the revelation of human-land contradictions and water supply management. Tracing the literature, soil erosion on the Loess Plateau in the middle reaches emerged as the basin's primary ecological problem. The “water-centric” approach to resource utilization led to the normalization of downstream flow cutoff by 1995, with increasing frequency, duration, and extent. Water resource pollution and quality deterioration further exacerbated supply-demand conflicts. In response, the state implemented the *Yellow River Water Quantity Dispatch Management Measures* in 1998, establishing unified management and scheduling of water resources. Scholars proposed multi-objective integrated water resource management mechanisms emphasizing joint water quantity and quality dispatching.

Stage 2: Derivative Development (2000–2011)

Research during this period concentrated on “ecological environment,” “human-land relationship,” “returning farmland to forest,” and related themes. Exploration of the basic connotations and theories of the human-land system evolved from single-resource development to systems theory, laying a foundation for subsequent research. Scholars first examined the human-land system's 内涵, evolutionary trajectory, and guiding ideology, clarifying its essence as an environmental-economic composite open giant system requiring systematic examination of contradictions. Studies demonstrated that meeting ecological base-flow and other environmental water demands in the Yellow River Basin largely resulted from ecological projects such as the Natural Forest Protection Program, the Grain for Green Project, and forest ecological benefit compensation initiatives that enhanced water conservation capacity.

Stage 3: Deepening Phase (2012–2018)

Research themes focused on “ecological protection,” “ecosystem,” “wetland,” and “spatial pattern.” The *National Main Functional Area Planning* implemented in 2010 emphasized comprehensive ecosystem governance and protection through territorial space development and ecological compensation. Scholars analyzed wetland resource distribution characteristics, constructed wetland protection frameworks, and demonstrated the strategic importance of prioritizing wetland protection for basin ecological security. Addressing insufficient farmer participation in ecological protection, proposals were made to improve ecological subsidy policies and coordinate balanced development across the basin. This stage represented further deepening of human-land system research, highlighting human pressures on the basin’s ecosystem and resulting environmental changes and their feedback on human systems—a process that evolved from “cognition” to “theory.”

Stage 4: Coupling Practice (2019–2022)

This stage aims to realize the “ecological protection and high-quality development” goals proposed by the central government, focusing on keywords such as “green development,” “ecological civilization,” “urban agglomeration,” “basin ecology,” “collaborative governance,” “driving factors,” and “coupling coordination.” The essence of the Yellow River Basin’s ecological protection and high-quality development strategy is promoting comprehensive basin civilization revival guided by ecological civilization. Scholars have actively investigated green high-quality development evaluation, spatial patterns and network structures of development, spatiotemporal evolution and driving factors of human-land coupling coordination, urban ecological boundaries, and coordinated development. Research has focused on deconstructing human-land system structures and interactions, revealing pathways and mechanisms for green industrial transformation, identifying obstacles to strategy implementation, and exploring green high-quality development pathways through human-land coupling.

3. Research Hotspots

Analysis of human-land relationship literature reveals that research hotspots have evolved from early investigations of system structure and function, to evaluation and evolution of human-land relationships, and subsequently to pathways for coordinated development. This progression follows the logical framework of “system structure—system evaluation—practical application.” Currently, scholarly attention concentrates on four primary areas: basin “production-living-ecological” space assessment, urban ecosystem and economic development, human-land system and territorial spatial development, and human-land coordination and high-quality development evaluation, while emphasizing integration of research data and methods.

3.1 Data Support for Human-Land System Research Data sources for human-land system research are categorized into three types: traditional data,

remote sensing data, and big data . Traditional socioeconomic data derive from field surveys and official statistics. Rapid advancements in satellite remote sensing, UAV aerial photography, network tracking, and artificial intelligence provide powerful support for human-land system research. The complementarity between remote sensing imagery and traditional data enables integration of qualitative and quantitative approaches, improving data precision and breadth. Big data, characterized by large volume, high processing speed, and accuracy, facilitates large-scale, high-precision spatial analysis and dynamic temporal continuity, enabling more precise “human-centered” research.

3.2 Human-Land System Structure and Function The human-land relationship regional system represents an important frontier in Earth system science research, offering new perspectives and theoretical frameworks for comprehensive human-land system studies [Figure 4: see original paper]. The theoretical model illustrates that the human-land system exhibits a dialectical unity relationship. On one hand, the “human” subsystem extracts material resources from the “land” subsystem, exerting pressure through population growth, economic development, and regional development intensity. On the other hand, the “land” subsystem serves as the foundation and crucial support for sustainable human-land relationships, encompassing resource-environmental endowments, carrying capacity, and governance, while providing environmental feedback to human activity systems.

3.3 Application Research Basin “Production-Living-Ecological” Space Assessment

The “production-living-ecological” space concept—encompassing intensive and efficient production space, livable and moderate living space, and ecologically sound environmental space—represents the evolutionary outcome of human-land relationship regional systems and constitutes the objective of territorial spatial optimization. Scholars have focused on functional evaluation and pattern evolution of “production-living-ecological” spaces in the Yellow River Basin. Functional evaluation research includes classification and assessment system construction, spatiotemporal differentiation analysis, and optimization regulation strategies. Pattern evolution studies reveal that from 1980 to 2018, the basin’s territorial space exhibited a continuous decrease in production space, expansion of living space, and dominant ecological space.

Urban Ecosystem and Economic Development

Urban areas, where human-land relationships are most intensely manifested, have become typical research regions. Studies demonstrate a significant decoupling between urban ecological footprint and economic growth in cities along the Yellow River, indicating improving human-land relationships. Scholars widely apply coupling coordination models, relative development models, and interactive stress models to explore interactions between ecological environment and economic development, as well as coupling coordination mechanisms and spatiotemporal characteristics. Using neighborhood three-way decision meth-

ods and urban ecosystem health evaluation models, researchers have classified Yellow River Basin cities into core economic circle cities, promising development cities, potential cities, and marginal cities, revealing spatial patterns of urban ecological construction and identifying multidimensional enhancement pathways.

Human-Land System and Territorial Spatial Development

Territorial space constitutes the primary arena for human survival and development and an important carrier for economic and social progress. The natural endowment of the Yellow River Basin forms the crucial geographical foundation for territorial spatial development and protection patterns. Scholars have evaluated resource endowments and security at the prefecture and provincial levels, assessed the value of forest and grassland ecosystem regulatory services in the basin's upper and middle reaches, and examined land use type conversion, development potential, and environmental effects. Research reveals that production space has shrunk, living space expanded, and ecological space fluctuated, with territorial development approaching critical thresholds. Additionally, scholars have investigated regional differences and convergence effects of carbon emission efficiency based on low-carbon development perspectives.

Human-Land Coordination and High-Quality Development Evaluation

Promoting human-land system coordination and sustainable development represents the core of the national strategy for ecological protection and high-quality development in the Yellow River Basin. Human-land coordination and spatial coordination are critical for basin-wide high-quality development. Evaluation methods have evolved from conventional coupling coordination analysis to three-dimensional visual spatial analysis. Evaluation dimensions have expanded from traditional two-dimensional “ecology-economy” coordination to three-dimensional “ecology-economy-society” synergistic management, and further to multidimensional coordination incorporating “population-resources-environment-economy-society-development.” Spatial coordination research has focused on measuring and analyzing the spatiotemporal evolution of high-quality development levels, employing multiple model integration and modern analytical tools such as standard deviation ellipse, spatial autocorrelation, and geographic detectors to explore green high-quality development patterns.

4. Research Frontiers

Burst terms refer to keywords with rapidly increasing frequency over specific periods. Higher burst intensity indicates greater short-term frequency, while longer duration suggests sustained research 热度. The Sigma index combines burstiness and centrality to reflect research novelty and frontier characteristics. Using CiteSpace's burst detection function, frontier trends in Yellow River Basin human-land system research were identified .

The analysis reveals that frontier hotspots include “Yellow River,” “water re-

sources,” “geographical environment,” “spatial pattern,” “green development,” and “urban agglomeration,” with burst intensities ranging from 1.01 to 7.18. “Water resources” shows the longest duration (1998–2013), followed by “Yellow River” (1992–2004), both with centrality values far exceeding the critical threshold of 0.1, indicating long-standing societal concern. The Yellow River’s management emphasizes protection and governance, with green development and urban agglomeration emerging as current research frontiers with burst intensities of 3.52 and 3.17, respectively.

Under the backdrop of ecological civilization, “geographical environment” and “spatial pattern” have become important research contents with burst intensities of 4.41 and 3.52 and sustained durations of 7 and 6 years, respectively. Scientific evaluation of basin ecological security, analysis of geographical element pattern evolution, and investigation of human-land system coupling mechanisms and regulation pathways hold broad research prospects. Future studies must analyze not only natural processes but also deepen methods for scale matching and transformation between natural and socioeconomic processes. Human-land system coupling models represent critical tools, with scholars proposing various evaluation methods including resource-environmental carrying capacity, ecological footprint, decoupling index, system dynamics, emergy analysis, and comprehensive integrated assessment. In the new era, human-land system research should embrace the big data era, promoting integration of “geographical processes and big data machine learning” for more accurate simulation and prediction of complex human-land relationships.

5. Conclusions and Outlook

Based on bibliometric analysis of human-land system research in the Yellow River Basin from 1992 to 2022, this study reveals: (1) The field has long been a societal concern, with early initiation and rich content, reaching unprecedented theoretical and practical heights since 2019. (2) The evolutionary trajectory comprises four stages: initial understanding, derivative development, deepening phase, and coupling practice. Research focus has shifted from water contradictions and pollution control to coordinated governance of water ecology, environmental system value assessment, and human-land system coupling. (3) Research hotspots have evolved from system structure and function to relationship evaluation and evolution, and subsequently to coordinated development pathways, following the logical framework of “system structure—system evaluation—practical application.” Current research emphasizes basin “production-living-ecological” space assessment, urban ecosystem and economic development, human-land system and territorial spatial development, and human-land coordination and high-quality development evaluation, with integrated data and methods.

Despite substantial accumulated experience and theoretical foundations, theoretical and practical innovation remains essential under the new era context marked by the “Two Mountains” theory and the *Yellow River Basin Ecological*

Protection and High-Quality Development Planning Outline. Future research should focus on:

1. **Extending and refining research domains.** Grounded in geographical thinking, research should emphasize interdisciplinary integration across ecology, engineering, environment, economics, and geography. While following established paradigms, interfaces with other research frameworks should be established to build micro-to-macro cross-scale paradigms for more systematic and comprehensive investigation. Research content should shift from single-resource utilization to territorial spatial development, particularly emphasizing integrated governance and systematic protection of mountains, rivers, forests, farmlands, lakes, grasslands, deserts, and ice.
2. **Innovating and developing analytical tools.** Despite its limitations, knowledge graph analysis should be combined with traditional literature analysis methods. Empirical research should be emphasized, including widespread adoption of structural models, decoupling models, and ecological product value realization approaches. Novel research methods and data sources should be explored and applied, such as “ecological rationality” improved upon “economic rationality,” “planning norms,” and “environmental psychology” as mainstream analytical tools.
3. **Constructing more comprehensive theoretical research systems.** The interaction mechanism between human and land systems in the basin constitutes a complex dynamic system. While tracking hotspots to effectively respond to practical concerns, more comprehensive and systematic theoretical frameworks must be established. Current research predominantly focuses on single factors such as land or water resources, with limited comprehensive integrated studies. Strengthening such integrated research will better facilitate coordination between human activities and environmental systems in economic and social development.

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