Bibliometric Analysis of Remote Sensing Research Progress and Hotspots in the Ebinur Lake Region: Postprint

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Abstract

As a typical arid region lake, the protection and research of Ebinur Lake hold significant importance for addressing ecological degradation and maintaining ecological balance. Remote sensing technology, characterized by its capability to provide large-scale, multi-scale, and multi-temporal continuous observation data, demonstrates substantial advantages in monitoring ecological and environmental changes of arid region lakes. This study employs CiteSpace software to conduct a visual bibliometric analysis of 340 articles on remote sensing research in the Ebinur Lake region from the China National Knowledge Infrastructure (CNKI) and Web of Science (WOS) databases spanning 1990–2023, comprehensively examining publication volumes, research forces, and research hotspots, thereby revealing the evolutionary trajectory, focal points, and shifting trends of related research. The results indicate that research in this domain commenced in 1990, undergoing an embryonic stage, a period of rapid growth, and a recent slowdown in development. While core author groups and research institutions have emerged, there remains room for enhancement in interdisciplinary collaboration. Research hotspots encompass topics related to Ebinur Lake, the Ebinur Lake wetland, and the Ebinur Lake basin, gradually transitioning from early-stage monitoring and analysis of lake surface variations and desertification toward diversified directions such as ecosystem service valuation, land use, and landscape pattern changes. This study provides a scientific foundation for comprehending the development trends of remote sensing technology research in the Ebinur Lake region and proposes recommendations for future research directions.

Full Text

Progress and Hotspot Analysis of Remote Sensing Research in the Ebinur Lake Area Based on Bibliometrics

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Abstract: As a typical lake in an arid zone, the protection of Ebinur Lake, Xinjiang, China is of great importance, and it is also the site of significant research regarding ecological degradation and maintaining ecological balance. Remote-sensing technology, which can provide large-scale, multi-scale, and multi-temporal continuous observational data, demonstrates great superiority in monitoring the ecological and environmental changes in lakes in arid areas. Using CiteSpace software, a literature visualization analysis was performed on 340 articles concerning remote-sensing technology research in the Ebinur Lake area from the CNKI and Web of Science (WOS) databases in 1990–2023. The number of publications, research groups, and research hotspots working in this field were comprehensively analyzed, and the evolution process, research foci, and their changing trends were revealed. The results indicate that research in this field began in 1990 and has passed through the embryonic and rapid-growth stages, recently entering a slow decline. Core author groups and institutions have been formed, but there remains room for improvement in interdisciplinary cooperation. The research hotspots include topics related to Ebinur Lake, its wetlands, and its basin, gradually shifting from early lake-surface change and desertification monitoring analysis to diversified approaches such as estimating ecosystem service value, land use, and landscape pattern changes. While remote-sensing technology research in the Ebinur Lake area has seen remarkable progress over the past several decades and has gradually formed a multidisciplinary research pattern, some challenges remain, and there are directions for future development: (1) The ecosystems in the Ebinur Lake area are diverse and unique, and large-scale, continuous remote-sensing monitoring data are lacking. In the future, continuous remote-sensing observations of the ecological dynamics in the Ebinur Lake area should be intensified. For instance, in terms of the seasonal and annual changes in the Ebinur Lake area and the dynamic conversion of surrounding types of land use, continuous remote-sensing observation data can more accurately reflect changing trends, providing more comprehensive data support for regional ecological protection and resource management. (2) The Artemia resources in Ebinur Lake can be evaluated using remote-sensing technology. Artemia is an important biological resource in Ebinur Lake, although there have been few remote-sensing studies of it here. Such an evaluation will promote the in-depth integration of remote-sensing technology and fishery resource science, as well as other fields, providing additional scientific and technological support

for resource management and ecological protection in the area around Ebinur Lake, promoting remote-sensing technology research in the Ebinur Lake area to develop in a more comprehensive and diversified direction.

Keywords: remote sensing technology; bibliometrics; visualization analysis; progress and hotspots; Ebinur Lake

The Ebinur Lake area, located in a critical zone on the northwestern frontier of China, constitutes an important ecological region within the Junggar Basin. Centered on Ebinur Lake and encompassing surrounding wetlands and the entire watershed, it was designated as the Ebinur Lake Wetland National Nature Reserve in 2007. Remote-sensing technology, with its capacity for large-scale, multi-temporal, and long-distance information acquisition, has become an essential tool for monitoring surface features in the Ebinur Lake area. However, existing studies have primarily employed qualitative description or single-case analysis methods to explore remote-sensing research on Ebinur Lake, lacking bibliometric analysis and systematic review of literature in this field. Although some scholars have conducted bibliometric analyses of lake remote-sensing progress domestically and internationally based on the Web of Science database, no comprehensive review of remote-sensing research specifically targeting the Ebinur Lake area has been reported. Bibliometrics, as an emerging discipline dominated by quantitative analysis, systematically studies literature data using mathematical and statistical methods to grasp and deeply understand hotspot issues and frontier dynamics in specific research fields.

Given this context, this study aims to conduct quantitative analysis and knowledge mapping of literature related to remote-sensing technology research in the Ebinur Lake area using the scientific literature analysis tool CiteSpace, analyzing publication volume, authors, research institutions, publication sources, discipline distribution, and the evolution of research hotspots. Through these comprehensive methods, this paper attempts to thoroughly analyze the development history of remote-sensing technology research in the Ebinur Lake area, assess the current research status, and provide predictions for future trends, thereby offering references and insights for remote-sensing technology research and its application in regional environmental monitoring and management, as well as providing scientific basis and effective approaches for ecological protection and rational resource utilization in the Ebinur Lake Wetland.

1.1 Data Sources

The widely used and authoritative academic resource databases CNKI (China National Knowledge Infrastructure) and Web of Science (WOS) Core Collection were selected as literature data sources. In CNKI, the China Journal Full-text Database, China Doctoral Dissertation Database, and China Master' s Thesis Full-text Database were searched for literature in the field of remote-sensing technology in the Ebinur Lake area. In the advanced search box, the search expression "SU=('Ebinur Lake' + 'Aibi Lake') AND SU=('remote

sensing' + 'RS' + 'remote-sensing' + '3S')" was used, with "Ebinur Lake" as the subject to supplement literature related to remote sensing. The earliest retrieved literature dated from 1990. After screening to remove conference papers and other literature unrelated to the research theme, as well as potentially duplicate literature, 315 Chinese-language articles were finally obtained. In the Web of Science Core Collection database, the search expression "TS=(Ebinur Lake OR Aibi Lake) AND TS=(remote sensing OR RS OR remote-sensing)" was used, with the earliest literature published in 2004. After manual screening, 25 English-language articles were obtained. The retrieval date was December 31, 2023. The settings for the bibliometric and visualization analysis process were as follows: (1) During bibliometric analysis, it was found that some authors published papers in both domestic and international journals, so their authors, institutions, and keywords were unified into Chinese for visualization analysis. (2) During visualization analysis, when running CiteSpace 6.3.R1, the node type was set to "Author," "Institution," and "Keyword," the time span was set to 1990–2023, the time slice was set to 1 year, and other parameters used default settings to obtain relevant collaboration network maps.

1.2.2 Author Analysis

According to Price' s law, the number of core authors is determined as those with more than N publications, where the threshold N is calculated as: $N = 0.749 \times \_\{\max\}$, where $\_\{\max\}$ represents the number of papers published by the most productive author, and N is the publication threshold.

2 Results and Analysis

2.1 Publication Volume Analysis

Analyzing the publication trend of research results can reveal the evolution of a research field on a temporal scale. Using NoteExpress software for bibliometric statistics, the publication years were exported, and the annual distribution of literature on remote-sensing technology in the Ebinur Lake area was plotted (Fig. 1). Among them, Chinese literature on remote-sensing technology in the Ebinur Lake area began earlier, with more publications than English literature. Research related to remote-sensing technology in the Ebinur Lake area first appeared in 1990, when the literature addressed natural and anthropogenic factors causing the shrinking of Ebinur Lake, discussed its impacts on the ecological environment, and proposed relevant suggestions for protecting the lake surface environment. However, for a long time thereafter, research progress in this field was quite slow, with no publications during that period.

From 1990 to 2007 was the embryonic stage of research in this field. Although the establishment of the reserve in 2007 had a positive impact, the number of papers published each year during this period was small, with fewer than 5 papers annually, indicating that although research had begun, it was still in the initial development stage, and scholars' attention to this field was gradually increasing.

From 2008 to 2020 was the rapid development period, with fluctuating growth in the number of publications, reaching a small peak in 2017. After 2021, it entered a period of slowed development. On the one hand, this was affected by epidemic control measures; on the other hand, the continuous reduction of the lake water area and increasingly harsh sampling environments limited investigation and sampling work in the Ebinur Lake Nature Reserve. Overall, the trend shows slow growth initially, followed by rapid growth, and finally a decrease due to multiple factors.

2.2.1 Publication Sources and Discipline Distribution

Among the top 10 Chinese sources for remote-sensing technology research in the Ebinur Lake area, *Arid Land Geography* ranks first (13 articles), followed by the *Journal of Agricultural Engineering* (6 articles). Most of these journals fall under natural sciences and agriculture categories, with the highest publication volumes in *Arid Land Geography* and the *Journal of Agricultural Engineering*, both with 6 articles, followed by the *Journal of Desert Research* with 5 articles. *Acta Ecologica Sinica* has the highest comprehensive influence in the field of remote-sensing technology in the Ebinur Lake area and represents an important journal in this field (Table 1). Due to the limited number of literature on remote-sensing technology research in the Ebinur Lake area in the WOS database, detailed listing is not provided here; most are journals above the Chinese Academy of Sciences Q4 level, with *Remote Sensing* having more publications (3 articles), accounting for 12% of English literature, making it a key academic journal.

Table 1 Top 10 Chinese sources for research papers on remote-sensing technology in the Ebinur Lake area

Note: Impact factor is the CNKI comprehensive impact factor, retrieved on January 1, 2024.

Environmental science and resource utilization is the discipline with the most publications in the CNKI database, with 57 articles accounting for 18.2% of Chinese literature, followed by physical geography and surveying and mapping (51 articles, 16.4%). Additionally, it involves multiple disciplines including agricultural basic sciences, agronomy, geophysics, and biology. In the WOS database, most literature falls under environmental science (67.9%), followed by water resources (26.8%). In summary, remote-sensing technology research in the Ebinur Lake area involves a wide range of disciplines, with environmental science as the main field gradually penetrating into other disciplines. The research content mainly includes monitoring of the ecological environment, water resource utilization, and land-use change in the Ebinur Lake area.

The positioning of academic journals is usually closely related to their disciplinary fields. Among the top 10 journals, those in the environmental science and resource utilization category rank first, followed by journals in physical geography and surveying and mapping. Chinese journals such as *Arid Land Geography* and *Journal of Arid Land Resources and Environment* typically involve

environmental science and resource utilization and physical geography, particularly focusing on resource management and environmental protection in arid zones. English journals such as *Remote Sensing* involve environmental science and water resources categories, covering research on water resource management, land degradation prevention and control, ecosystem protection and restoration, etc., to address the impacts of climate change on arid regions. Secondly, in the field of biology, these journals such as *Acta Ecologica Sinica* publish research on endemic species in arid zones and species diversity in ecosystems, involving ecological protection and sustainable utilization of biological resources. In addition, Chinese journals such as *Spectroscopy and Spectral Analysis* also span other related disciplinary fields such as physics and chemistry, while English journals such as *Remote Sensing* also involve remote sensing, earth science, imaging science, and photographic technology, reflecting the multidisciplinary cross-cutting characteristics of remote-sensing technology research in the Ebinur Lake area.

2.2.2 Authors and Research Institutions

Among the top 10 authors by publication volume in the CNKI and WOS databases, centrality indicates the mediating role of a node in the entire network. In terms of authors, Zhang Fei is the most productive author with 11 publications, followed by Ding Jianli with 10 publications. These two highly productive authors also have relatively high centrality, indicating close collaboration with other authors. According to Price' s law, the calculated threshold N 6.31, so there are 11 core authors with more than 6 publications. Core authors have played a leading role in remote-sensing technology research in the Ebinur Lake area and continuously expanded their research content. The publication of relevant literature in this field has formed an international collaborative group with Zhang Fei, Ding Jianli, Wang Jingzhe, and Kung Hsiang-te as core authors, with nodes connecting to each other. The research team of Zhang Fei, Duan Pan, and Kung Hsiang-te focuses on monitoring suspended particulate matter in Ebinur Lake using high spatiotemporal resolution images. The research team of Ding Jianli, Wang Jingzhe, and Ge Xiangyu focuses on extracting the Ebinur Lake wetland using Landsat series data and exploring its spatiotemporal dynamics.

Table 2 Top 10 authors of remote-sensing technology research publications in the Ebinur Lake area

For Artemia information extraction in Ebinur Lake, research remains relatively limited. For example, Li Wei from Dalian Ocean University uses multispectral imagery to analyze the spectral characteristics of different water bodies in the Ebinur Lake area and constructs extraction models for Artemia egg band information. Wang Xin from Wuhan University uses HY-1C CZI data and sliding window cropping with spectral matching factor technology to construct a water body dataset and precisely extracts Artemia bands using the C2RCC algorithm. Tian Liqiao from Wuhan University developed a multispectral optical sensor detection method based on Landsat-8 OLI data by analyzing the aggregation patterns and optical characteristics of Artemia eggs, creating a brine shrimp

index for automatic identification and monitoring of Artemia distribution.

The institution with the most publications is Xinjiang University (57.4%), followed by Xinjiang Agricultural University (17.7%) and Xinjiang Normal University (16.4%), constituting the main components of research. The remaining nodes are connected through these institutions, forming close collaborative relationships (Fig. 3). Geographically, research institutions are unevenly distributed, mainly concentrated in northwestern China, particularly Xinjiang, where scholars have conducted in-depth research in this field, likely due to these institutions' proximity to the study area. In summary, domestic and foreign authors and research institutions show relatively high concentration, with Xinjiang University as the core and other universities as the main body, forming a close scientific research collaboration network. Moreover, this field has extensive collaborative relationships, including not only research institutes such as the Xinjiang Institute of Ecology and Geography of the Chinese Academy of Sciences and the Xinjiang Academy of Environmental Protection Science, but also relevant government departments, together constituting an important force in remote-sensing technology research in the Ebinur Lake area.

Figure 3 [Figure 3: see original paper] Author and institutional collaboration network maps of remote-sensing technology research in the Ebinur Lake area

2.3.1 Keyword Co-occurrence Network Analysis

Keywords represent the refined expression of an article' s core research content. By analyzing keywords, we can grasp research hotspots and their development changes in a certain field. Using CiteSpace software for keyword visualization analysis, after pruning algorithms and manual adjustment, the top 25 high-frequency keywords were retained (Fig. 4). Nodes represent keywords, with size indicating frequency—the larger the circle, the higher the frequency. The top-ranked high-frequency keywords include "Ebinur Lake," "remote sensing," "landscape pattern," "dynamic change," "land use," "land use/land cover (LUCC)," "ecosystem service value," "machine learning," "geographic information system (GIS)," and "soil." Among them, "Ebinur Lake" and "remote sensing" are the keywords with the largest nodes and highest frequency. However, since "Ebinur Lake + remote sensing" was used as the screening term in this retrieval process, these will not be discussed further. High-frequency keywords do not always have high centrality, so relying solely on high-frequency words cannot accurately identify research themes in this field. Keywords with relatively high centrality include soil (0.18), oasis (0.15), lake surface change (0.12), and machine learning (0.11), indicating that these keywords play key intermediary roles in remote-sensing technology research in the Ebinur Lake area.

Figure 4 [Figure 4: see original paper] Keyword network map of remote-sensing technology research in the Ebinur Lake area

2.3.2 Keyword Clustering Analysis

To better understand research themes and hotspots, the log-likelihood rate algorithm in CiteSpace software was used for clustering analysis (Fig. 5), forming cluster labels. The study found that the clustering module value $Q = 0.9638$, meaning the clustering structure is significant, and the clustering average silhouette value $S = 0.8713$, indicating credible clustering results. The top 10 larger keyword clusters are ranked in order as: soil, oasis, lake surface change, machine learning, human activities, spectral characteristics, and dynamic degree. There is high overlap between clusters, indicating that previous research has continued and expanded, while certain relationships exist among clusters.

Figure 5 [Figure 5: see original paper] Keyword clustering map of remote-sensing technology research in the Ebinur Lake area

2.3.3 Keyword Emergence and Timeline Analysis

To intuitively reflect the relationships between keyword clusters, their time spans, and display keyword changes over time, CiteSpace was used to set analysis parameters to "Burst terms" to generate a keyword emergence map (Fig. 7). The timeline represents the overall time range (1990–2023), with the light blue portion representing the time slice (1990–2023). The emergence time range is filled in red, while years with less obvious emergence changes are filled in dark blue. The terms with higher emergence rates are landscape pattern (emergence rate 6.58) and spectral index (emergence rate 5.05).

Through in-depth analysis of the keyword timeline map (Fig. 6) and emergence map (Fig. 7), combined with relevant literature, the following conclusions were drawn: (1) From 1990 to 2007, the impact of Ebinur Lake retreat on the ecological environment was studied based on remote-sensing technology. In 2007, when the Ebinur Lake Wetland was approved as an autonomous region-level reserve, the literature volume increased significantly. Research hotspots included geographic information system (GIS), lake surface change, desertification, and arid zones, with research focusing on lake surface change monitoring and desertification monitoring. (2) After being promoted to a national-level reserve in 2013, the research scope expanded. Previous hotspots continued, and new hotspots such as landscape ecology, shrub sand dunes, soil erosion, desertification, and dynamic change emerged, with research beginning to focus on landscape ecological classification and ecological security assessment. (3) During the "13th Five-Year Plan" period (2016–2020), influenced by the implementation of the "China Ebinur Lake Area Sustainable Management and Biodiversity Conservation Project," in-depth monitoring and analysis of soil salinization and desertification were conducted, such as spatiotemporal evolution studies of soil salinization, dynamic degree studies of desertification processes, and land use/land cover studies. (4) From 2021 to the present, research has focused on the application of spectral technology in environmental monitoring, covering vegetation, water bodies, and soil, while also paying attention to ecosystem service value

and changes in land use and landscape patterns. (5) "Machine learning" and "Google Earth Engine" have become frontier fields. Additionally, the Ebinur Lake Wetland has been listed as a key area for national wetland protection. Overall, literature from the five different periods shows significant consistency with the development of remote-sensing technology, policy environments, and contemporary requirements.

Figure 6 [Figure 6: see original paper] Timeline map of keyword development in remote-sensing technology research for the Ebinur Lake area

Figure 7 [Figure 7: see original paper] Top 25 emerging word map of remote-sensing technology research in the Ebinur Lake area

Further review of literature content on remote-sensing research in the Ebinur Lake area reveals that the research scope can be divided into three levels from small to large: Ebinur Lake, Ebinur Lake Wetland, and Ebinur Lake Basin. Research perspectives can be summarized into macro and micro aspects, and the reasons for changes in research direction can be divided from the perspective of disciplinary development into basic, developmental, and deep stages.

3.1 Research Scope

Remote-sensing research in the Ebinur Lake area covers three aspects: lake, wetland, and watershed, focusing mainly on the following areas:

3.1.1 Ebinur Lake

(1) **Lake area change and climate factors:** Using remote-sensing data and climate models to analyze the dynamic changes in Ebinur Lake area and its relationship with climate factors (such as precipitation, evaporation) and human activities (such as agricultural irrigation, urban expansion). (2) **Water quality and suspended particulate matter monitoring:** Using remote-sensing technology, water quality index models, and machine learning methods to monitor and assess water quality conditions in Ebinur Lake, with a focus on suspended particulate matter concentration. (3) **Hydrological characteristics and topography research:** Using remote-sensing imagery and digital elevation models to study the underwater topography of Ebinur Lake and hydrological cycle characteristics (such as evapotranspiration), providing scientific basis for lake water resource management. (4) **Environmental impacts of dried lakebed:** Exploring the impact of Ebinur Lake retreat on the surrounding environment, particularly the formation mechanism of sandstorms on the dried lakebed, and assessing potential risks to regional climate and ecosystems. (5) **Ecological status and biodiversity:** Using remote-sensing technology to monitor water storage, water demand, phytoplankton biomass, and other ecological indicators in Ebinur Lake, using Artemia as an indicator species to assess lake ecosystem health and biodiversity.

3.1.2 Ebinur Lake Wetland

(1) **Soil characteristics and salinity analysis:** Using remote-sensing and geographic information system technology to monitor soil salinity, organic carbon, and inorganic carbon distribution in Ebinur Lake Wetland, analyzing soil salinization and desertification trends and assessing ecological risks. (2) **Land use and cover change:** Based on multi-source remote-sensing data, analyzing the spatiotemporal characteristics of land use/cover change in Ebinur Lake Wetland, predicting future change trends, and assessing their correlation with landscape patterns. (3) **Ecosystem service value and biodiversity monitoring:** Evaluating the ecosystem service functions of Ebinur Lake Wetland (such as windbreak and sand fixation), monitoring plant community structure and diversity, and revealing wetland ecological status and health levels. (4) **Environmental change and ecological disturbance:** Analyzing the degree of disturbance to the Ebinur Lake Wetland ecosystem by human activities and natural factors, assessing long-term impacts on ecosystem services, and exploring the relationship between landscape pattern change and ecological security.

3.1.3 Ebinur Lake Basin

(1) **Climate impact and vegetation dynamics:** Studying the impact of climate change on vegetation coverage, landscape patterns, and resource plant development patterns in the Ebinur Lake Basin. (2) **Water resources and hydrological research:** Analyzing water resource carrying capacity in the Ebinur Lake Basin and the impact of water supply and demand changes on lake area, as well as changes in river systems and hydrological characteristics. (3) **Landscape pattern and ecological risk:** Studying the spatiotemporal changes in landscape patterns, ecological risk assessment, and relationships with environmental factors in the Ebinur Lake Basin, and simulating and predicting dynamic changes in landscape patterns. (4) **Environmental monitoring and assessment:** Evaluating the ecological environmental quality of the Ebinur Lake Basin, diagnosing environmental health conditions using remote-sensing technology, and analyzing temporal and spatial variation characteristics of ecosystem service value. (5) **Ecological restoration and management:** Exploring goals, methods, and specific measures for ecological restoration in the Ebinur Lake Basin, delineating ecological protection areas, and proposing environmental governance solutions.

3.2 Research Angle

The application scope and depth of remote-sensing technology in the Ebinur Lake area continue to expand, with remarkable achievements made. Research angles are divided into micro and macro levels: the micro level focuses on monitoring single objects and extracting precise data, while the macro level emphasizes overall trends and large-scale environmental changes. From a micro

perspective, qualitative studies of single objects include lake water bodies, wetland vegetation, and land cover types, while quantitative research focuses on lake area, water depth, water storage, and water quality, vegetation area, coverage, and biomass, land cover type area, and soil physicochemical parameters. From a macro perspective, research themes on Ebinur Lake emphasize hydrological and ecological characteristic changes of the lake itself, Ebinur Lake Wetland research highlights wetland ecosystem health, biodiversity conservation, and environmental protection, while the Ebinur Lake Basin focuses on comprehensive environmental monitoring and assessment at the watershed scale.

3.3.1 Basic Stage

In the early stage, remote-sensing technology was limited, with low satellite image resolution and few data types. Research could only focus on basic geographic features of Ebinur Lake (such as shorelines and rough identification of large-area land use types). When remote-sensing discipline was in its infancy, research on the Ebinur Lake area aimed to explore technology applicability. Due to limited understanding, researchers started with acquiring basic geographic information to lay the foundation for subsequent research.

3.3.2 Development Stage

Satellite technology development brought new sensors and multi-source data (radar, hyperspectral, etc.), with data fusion providing more comprehensive information and promoting research transformation toward ecological environment monitoring (such as using hyperspectral data for precise water quality analysis). The development of ecology and other disciplines promoted interdisciplinary integration with remote sensing. Global emphasis on ecological environments increased research demand on ecosystems such as Ebinur Lake Wetland, requiring multidisciplinary comprehensive monitoring of ecological factors.

3.3.3 Deep Stage

Single disciplines cannot comprehensively understand the Ebinur Lake area, so interdisciplinary research on ecological-social systems should be conducted to formulate scientific strategies. Modern science emphasizes decision support for sustainable development, and remote-sensing research on Ebinur Lake provides support for resource management decisions (Artemia harvesting, land use planning, natural disaster warning and response, etc.).

4 Conclusions and Outlook

Comprehensive application of remote-sensing, geographic information systems, ecological models, and other technical means in remote-sensing research on the Ebinur Lake area has revealed environmental characteristics, ecological processes, and human activity impacts of the lake, wetland, and watershed from

multiple dimensions, providing important scientific basis for regional ecological environmental protection and sustainable development.

4.1 Conclusions

(1) In terms of publication volume, Chinese literature on remote-sensing technology in the Ebinur Lake area began earlier, with more publications than English literature. The development trend shows significant stage changes: from the first publication in 1990, through the embryonic period to 2007, the rapid development period from 2008 to 2020, and the slowed development period after 2021. This indicates that after a period of active development, the research field is currently in an adjustment and transformation stage due to factors such as the pandemic. (2) In terms of research strength, analysis of publication sources and discipline distribution shows that among the top 10 journals, those in environmental science and resource utilization rank first, showing multidisciplinary cross-cutting characteristics. Analysis of authors and research institutions indicates that core author groups and major research institutions have been formed, with relatively high concentration of domestic and foreign authors and institutions, centered on Xinjiang University and composed of other universities, research institutes, and government departments, together constituting an important force in remote-sensing technology research in the Ebinur Lake area. (3) Analysis of research hotspots and trends shows that early scholars focused on lake surface change and desertification monitoring, laying the foundation for understanding regional environmental changes. Later research began to focus on landscape ecological classification and ecological security assessment of the Ebinur Lake Basin, marking a transformation toward ecological and environmental effects. As research directions further expanded and deepened, monitoring, assessment, and improvement of soil salinization and desertification became new research hotspots, reflecting the deepening and enhanced comprehensiveness of the research field. In recent years, research on the application of spectral technology in environmental monitoring and changes in ecosystem service value has received widespread attention. These changes in research hotspots reflect the field' s pace with social needs and scientific and technological progress. (4) In-depth analysis of literature shows that research scope can be divided into Ebinur Lake, Ebinur Lake Wetland, and Ebinur Lake Basin, with research angles divided into micro and macro aspects. The micro angle focuses on monitoring single objects and extracting precise data, while the macro angle emphasizes overall trends and large-scale environmental changes. The reasons for changes in research direction can be divided from the perspective of disciplinary development into basic, developmental, and deep stages.

4.2 Outlook

(1) The ecosystems in the Ebinur Lake area are diverse and unique, yet large-scale continuous remote-sensing monitoring data are lacking. Future research should intensify continuous remote-sensing observations of ecological dynamics in the Ebinur Lake area. For example, regarding seasonal and annual changes in lake water area and dynamic conversion of surrounding land use types, continuous remote-sensing observation data can more accurately reflect changing trends, providing more comprehensive data support for regional ecological protection and resource management. (2) Remote-sensing technology should be used to evaluate Artemia resources in Ebinur Lake. Artemia is an important biological resource in Ebinur Lake, but there are currently few remote-sensing studies on it. This evaluation will promote deep integration between remote-sensing technology and fishery resource science, providing more scientific and technological support for resource management and ecological protection in the Ebinur Lake area, and promoting the development of remote-sensing technology research in this region toward a more comprehensive and diversified direction. (3) The capability of remote-sensing technology for disaster early warning in the Ebinur Lake area should be enhanced. The region may face natural disasters such as drought and wind-sand, and the application of remote-sensing technology in disaster early warning needs improvement. Future research should optimize algorithms and models to use remote-sensing data for timely monitoring of disaster signs and early warning, such as monitoring soil moisture and vegetation coverage indicators to provide early warnings of drought disasters, thereby offering strong support for regional disaster prevention and mitigation.

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