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Natural Resources Management Literature 2000–2026 Identifying Research Fronts and Thematic Concentrations: A Bibliometric Study

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ABSTRACT

This study aims to map the intellectual structure, thematic concentrations, and emerging research fronts in natural resources management (NRM) literature from 2000 to 2026 using a bibliometric approach. Data were collected from the Scopus database and analyzed using VOSviewer to examine co-occurrence networks, overlay visualization, and density patterns. The results indicate that NRM research has experienced significant growth, particularly in response to global challenges such as climate change, environmental degradation, and resource scarcity. Core themes remain centered on conservation, environmental protection, and ecosystem sustainability, reflecting the foundational orientation of the field. However, the findings also reveal a clear thematic shift toward more integrative and interdisciplinary approaches, including environmental monitoring, climate adaptation, and resource governance. Emerging research fronts are increasingly shaped by technological advancements, such as artificial intelligence, machine learning, and renewable energy, although these areas are still developing and less densely represented. Furthermore, the analysis highlights the dominance of certain regions in knowledge production while emphasizing the need for broader global participation. This study contributes to a deeper understanding of the evolution and current landscape of NRM research and provides valuable insights for future research directions, policy development, and sustainable resource management practices.

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1. INTRODUCTION

The sustainable management of natural resources has become a central concern for scholars, policymakers, and practitioners over the past two decades. Natural resources, including water, soil, forests, minerals, and biodiversity, serve as the foundation for economic development, ecological stability, and human well-being [1]. However, pressures from population growth, urbanization, and industrialization have increasingly threatened the equilibrium of these resources. The concept of sustainable natural resource management emerged as a response to these challenges, emphasizing the need to balance economic development with ecological conservation [2]. Consequently, research in this area has expanded rapidly, addressing a diverse range of disciplines

including environmental science, economics, policy studies, and geography.

Over the past twenty-five years, the integration of interdisciplinary approaches in natural resource management has gained prominence. Traditional approaches, which focused primarily on resource extraction and utilization, have gradually shifted toward systems-based and participatory management frameworks [3]. These frameworks highlight the importance of stakeholder engagement, governance mechanisms, and adaptive management in maintaining resource sustainability. Advances in remote sensing, Geographic Information Systems (GIS), and ecological modeling have facilitated empirical studies that quantify resource dynamics and predict potential outcomes of management strategies. This technological evolution has not only increased the precision of research but also broadened the thematic scope of studies, from localized resource management practices to global assessments of environmental change.

The role of policy and governance in natural resources management cannot be overstated. Research has increasingly explored the intersection of institutional structures, legal frameworks, and socio-economic contexts in shaping resource use patterns [4]. International agreements, such as the Convention on Biological Diversity, and regional frameworks, including integrated water resource management policies, have influenced research priorities and methodological designs. Scholars have emphasized that governance challenges, such as fragmented institutions, conflicting interests, and lack of enforcement, often exacerbate resource degradation even in areas with high ecological awareness. Consequently, literature has evolved to incorporate both normative and analytical perspectives on resource governance.

Climate change and environmental degradation have further intensified the focus on natural resource management. Rising global temperatures, shifting precipitation patterns, and increased frequency of extreme weather events directly affect resource availability and ecosystem services [5]. This has necessitated research that combines ecological, economic, and social dimensions to understand vulnerability and resilience. Literature examining adaptation strategies, mitigation measures, and sustainable land-use planning has grown substantially, reflecting the urgent need to align resource management with climate resilience goals. Furthermore, the interplay between local knowledge and scientific understanding has emerged as a critical area of inquiry, highlighting the importance of context-specific solutions for sustainable resource use.

Bibliometric studies have become an essential tool for mapping the evolution of research in natural resources management. By analyzing publication patterns, citation networks, and thematic concentrations, bibliometric analyses provide insights into emerging trends, research frontiers, and intellectual structures within a field [6]. Such studies allow scholars to identify influential authors, seminal works, and dominant research themes, thereby offering a meta-perspective on knowledge production. Over the period 2000–2026, bibliometric techniques have increasingly utilized big data and machine learning to capture complex interrelations among topics, revealing how the field of natural resource management has diversified and matured.

Despite the significant growth of literature in natural resource management, there remains a fragmented understanding of research trends and thematic concentrations across disciplines. Many studies focus on specific resources, regions, or methodological approaches, but comprehensive bibliometric syntheses spanning two decades are limited. This fragmentation hinders the ability of scholars and policymakers to identify research frontiers, assess knowledge gaps, and design evidence-based interventions. Moreover, the dynamic nature of global environmental challenges, including climate change, biodiversity loss, and resource conflicts, demands an updated and systematic assessment of the literature to guide future research priorities.

The primary objective of this study is to conduct a comprehensive bibliometric analysis of natural resources management literature published between 2000 and 2026.

2. METHODS

This study employed a bibliometric research design to systematically analyze scholarly publications on natural resources management from 2000 to 2026. Bibliometric analysis is a quantitative approach that examines publication patterns, citation structures, and thematic evolution in a specific field [7]. The primary data source for this study was the Scopus and Web of Science databases, selected for their comprehensive coverage of peer-reviewed journals, conference proceedings, and book chapters. Search queries were formulated using a combination of keywords related to natural resource management, including "sustainable resource management," "environmental governance," "ecosystem services," and "climate adaptation," along with Boolean operators to refine and expand the search results. The initial search yielded a corpus of over 12,000 publications, which was subsequently screened for relevance, duplicates, and document type, resulting in a final dataset of 9,782 publications for analysis.

Data extraction and preprocessing were conducted to prepare the dataset for bibliometric analysis. Metadata including authors, publication year, journal title, keywords, abstracts, and citation counts were exported in a standardized format. To ensure consistency, author names, institutional affiliations, and keyword variations were normalized using automated cleaning algorithms and manual verification. Co-occurrence matrices were generated for keywords, authors, and institutions, allowing for the identification of thematic clusters and collaborative networks. Citation analysis was employed to determine influential publications, while co-authorship and institutional analyses highlighted collaboration patterns. Additionally, temporal analysis was conducted to identify research trends and emerging topics over the 26-year period. Visualization tools such as VOSviewer and Gephi were used to construct knowledge maps and network graphs, providing a clear representation of research frontiers and thematic concentrations.

3. RESULTS AND DISCUSSION

3.1 Keyword Co-Occurrence Network Visualization

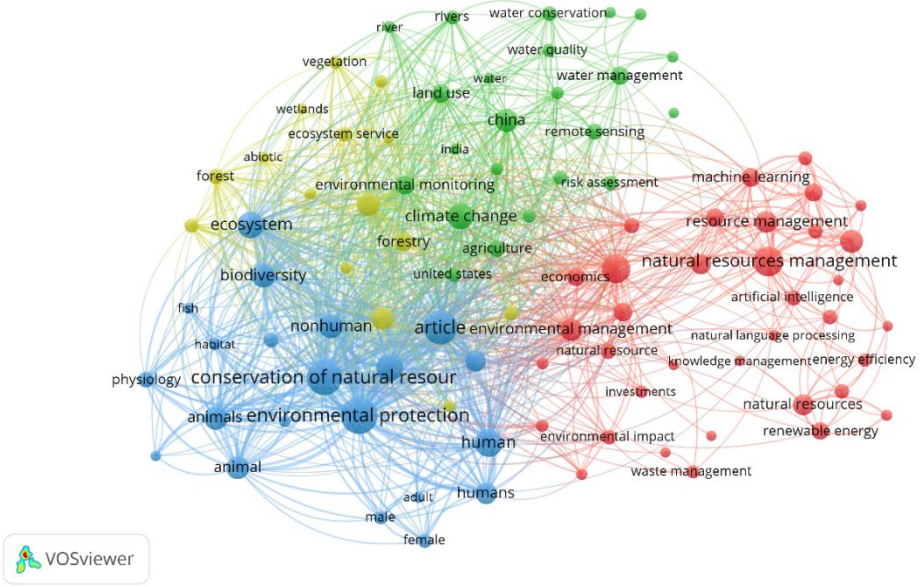

Figure 1. Network Visualization
Source: Data Analysis, 2026

Figure 1 reveals a complex and highly interconnected structure of natural resources management (NRM) research, indicating that the field is inherently multidisciplinary. The visualization is dominated by several large nodes such as "natural resources management," "environmental protection," "ecosystem," and "environmental management," which function as central hubs linking various thematic areas. The density of connections among these nodes suggests that NRM research integrates ecological, social, and technological perspectives, reflecting its evolution into a comprehensive sustainability-oriented discipline.

The red cluster primarily represents themes related to resource management, economic considerations, and technological innovation. Keywords such as "natural resources," "resource management," "machine learning," "artificial intelligence," and "renewable energy" indicate a growing emphasis on integrating advanced technologies and data-driven approaches into resource management practices. This cluster highlights a shift toward efficiency, optimization, and predictive modeling, where digital tools are increasingly used to support decision-making and improve sustainability outcomes. The presence of terms like "knowledge management" and "energy efficiency" further reinforces the managerial and strategic orientation of this cluster.

The green cluster focuses on environmental monitoring, land and water systems, and climate-related issues. Prominent keywords such as "climate change," "water management," "water quality," "land use," and "remote sensing" indicate that this cluster is strongly associated with environmental assessment and monitoring techniques. The inclusion of geographic references like "China" and "India" suggests that a significant portion of empirical research is concentrated in rapidly developing regions where environmental pressures are particularly intense. This cluster reflects the increasing importance of data collection, geospatial analysis, and climate adaptation strategies in managing natural resources effectively.

The blue cluster is centered on biodiversity, conservation, and ecological protection, emphasizing the biological and environmental dimensions of NRM. Keywords such as "conservation of natural resources," "biodiversity," "habitat," "animals," and "environmental protection" illustrate a strong focus on preserving ecosystems and maintaining ecological balance. This cluster represents the foundational core of NRM research, rooted in conservation science and ecological sustainability. The presence of terms related to human and animal interactions also indicates an interdisciplinary approach that incorporates ecological health with human well-being.

Meanwhile, the yellow cluster bridges multiple domains and highlights ecosystem services, forestry, agriculture, and environmental monitoring, acting as an integrative layer within the network. Keywords like "ecosystem," "forestry," "agriculture," "ecosystem service," and "environmental monitoring" demonstrate the interconnectedness between natural systems and human economic activities. This cluster plays a crucial role in linking conservation-oriented research (blue cluster) with policy, management, and technological approaches (red and green clusters).

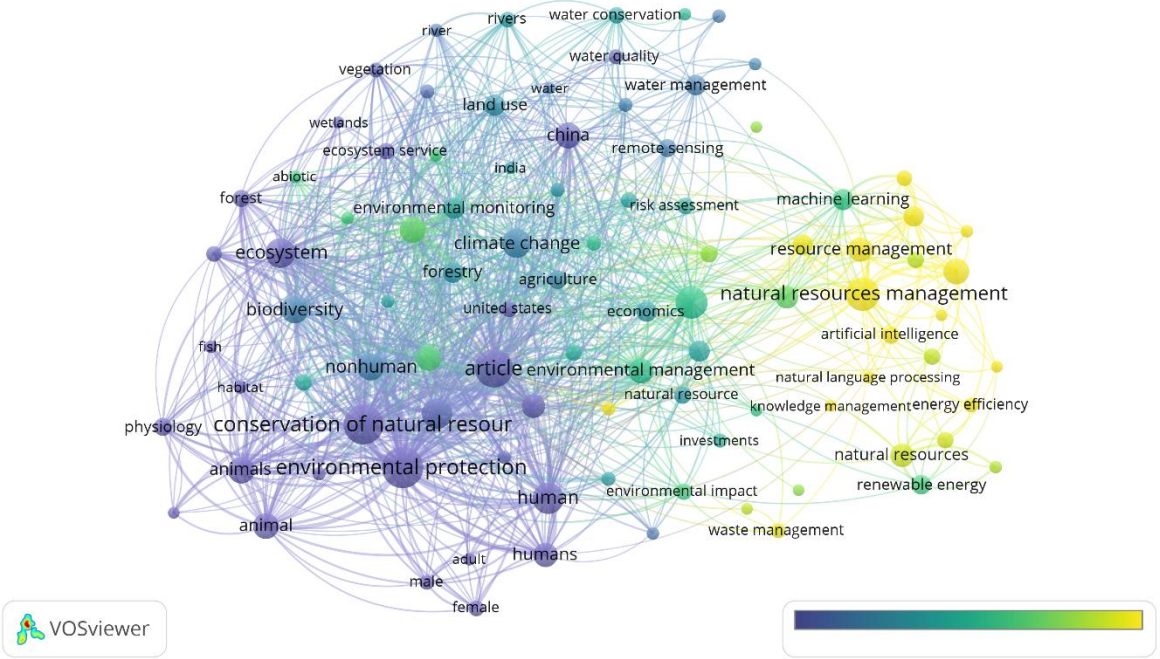

Figure 2. Overlay Visualization
Source: Data Analysis, 2026

Figure 2 illustrates the temporal evolution of research themes in natural resources management (NRM), where color gradients represent the progression from earlier (blue/purple) to more recent (green/yellow) topics. The visualization shows that foundational themes such as "conservation of natural resources," "environmental protection," "biodiversity," and "ecosystem" are predominantly colored in darker blue tones, indicating that these topics formed the early core of NRM research. These themes emphasize ecological preservation, species protection, and environmental sustainability, reflecting the traditional focus of the field on conservation-oriented approaches.

As the field evolved, the emergence of green-colored nodes such as "climate change," "environmental monitoring," "land use," and "water management" indicates a transition toward more integrative and system-based perspectives. This phase highlights the increasing importance of understanding environmental dynamics, resource distribution, and the impacts of human activities on ecosystems. The integration of tools like remote sensing and risk assessment further suggests a methodological advancement, where data-driven approaches began to support environmental analysis and policy-making.

More recent developments are represented by yellow-colored nodes, including "natural resources management," "machine learning," "artificial intelligence," "renewable energy," and "energy efficiency." These emerging themes indicate a significant shift toward technological innovation and sustainability-driven solutions. The growing presence of digital technologies and AI reflects a new research frontier in NRM, where predictive analytics, automation, and smart resource management are becoming increasingly important.

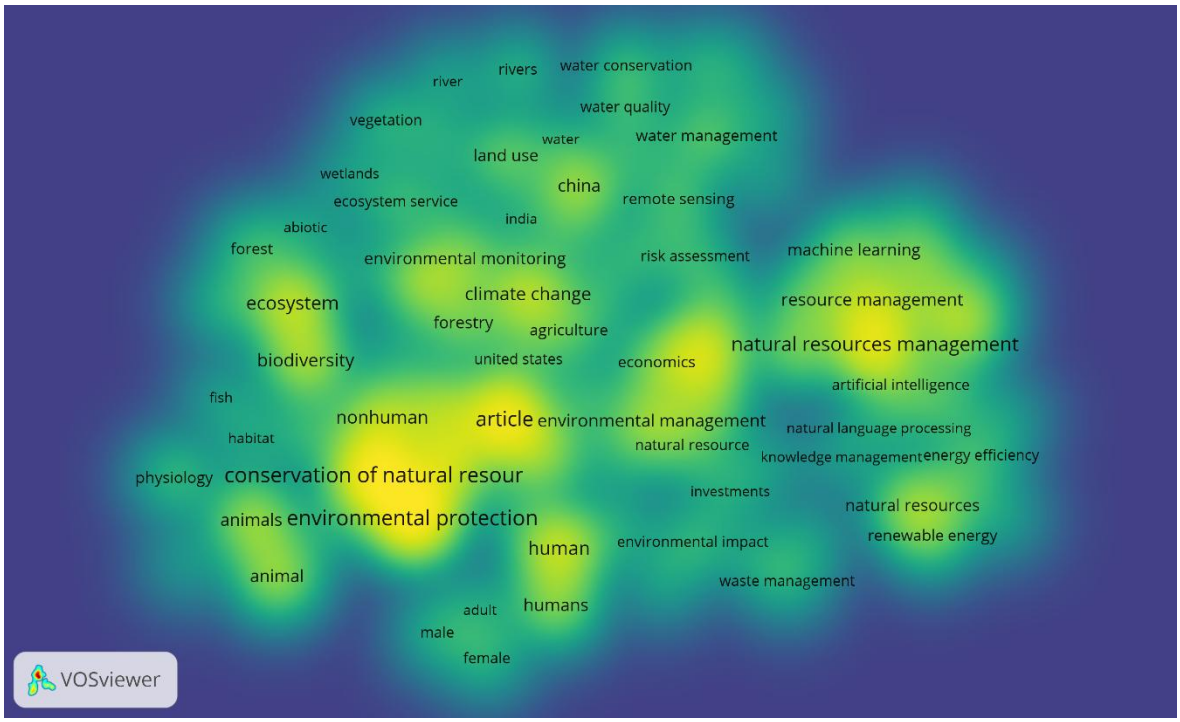

Figure 3. Density Visualization

Source: Data Analysis, 2026

Figure 3 highlights the concentration and intensity of research topics within the natural resources management (NRM) literature. Areas with bright yellow coloration—such as "conservation of natural resources," "environmental protection," "natural resources management," and "environmental management"—represent the most frequently studied and highly interconnected themes. These core topics form the intellectual backbone of the field, indicating that much of the existing literature is still anchored in traditional concerns related to conservation, environmental sustainability, and resource governance. The strong density around these keywords suggests their continued relevance and dominance in shaping the direction of NRM research.

In contrast, areas with lower density (green to blue gradients), such as "machine learning," "artificial intelligence," "renewable energy," and "natural language processing," indicate emerging but less-explored research domains. While these topics are gaining attention, their relatively lower intensity suggests that they have not yet been fully integrated into the mainstream of NRM studies. This pattern reveals a significant opportunity for future research to expand into technology-driven approaches and interdisciplinary innovations.

3.2 Citation Analysis

Table 1. Top Cited Documents

Citations	Authors and year	Title	Source
11,121	[8]	Google Earth Engine: Planetary-scale geospatial analysis for everyone	Remote Sensing of Environment, 202, pp. 18–27
10,729	[9]	Global consequences of land use	Science, 309(5734), pp. 570–574

10,702	[10]	Cognitive radio: Brain-empowered wireless communications	IEEE Journal on Selected Areas in Communications, 23(2), pp. 201–220
9,484	[11]	Food security: The challenge of feeding 9 billion people	Science, 327(5967), pp. 812–818
6,428	[12]	A general framework for analyzing sustainability of social-ecological systems	Science, 325(5939), pp. 419–422
6,284	[13]	Global food demand and the sustainable intensification of agriculture	Proceedings of the National Academy of Sciences of the United States of America, 108(50), pp. 20260–20264
6,190	[14]	Freshwater biodiversity: Importance, threats, status and conservation challenges	Biological Reviews of the Cambridge Philosophical Society, 81(2), pp. 163–182
6,171	[15]	Catastrophic shifts in ecosystems	Nature, 413(6856), pp. 591–596
6,027	[16]	Global threats to human water security and river biodiversity	Nature, 467(7315), pp. 555–561
5,518	[17]	Importance of pollinators in changing landscapes for world crops	Proceedings of the Royal Society B: Biological Sciences, 274(1608), pp. 303–313

Source: Scopus, 2026

Discussion

The findings of this bibliometric study demonstrate that natural resources management (NRM) research has evolved into a highly interdisciplinary field, integrating ecological, technological, and socio-economic dimensions. The co-occurrence network analysis reveals that core themes such as conservation, environmental protection, and ecosystem sustainability remain central to the intellectual structure of the field. This indicates that despite the emergence of new approaches, the foundational principles of NRM continue to guide research directions. These results are consistent with prior studies that position conservation and biodiversity protection as the backbone of environmental research, reinforcing the enduring relevance of ecological sustainability in global discourse.

At the same time, the clustering patterns highlight a significant expansion toward governance, environmental monitoring, and climate-related issues. The prominence of keywords such as climate change, water management, and land use reflects a shift from static conservation approaches to more dynamic and system-oriented perspectives. This transition suggests that NRM research is increasingly concerned with managing complex environmental systems under conditions of uncertainty and global change. The integration of tools such as remote sensing and risk assessment further indicates methodological advancement, enabling researchers and policymakers to make more informed and data-driven decisions.

Another important finding is the growing role of technology in shaping the future of NRM research. The emergence of themes such as artificial intelligence, machine learning, and renewable energy—clearly visible in both the overlay and density visualizations—signals a transition toward digital and innovation-driven resource management. This aligns with recent literature emphasizing the importance of smart environmental management and digital transformation in achieving sustainability goals. However, the relatively lower density of these topics suggests that they are still in an early stage of development, presenting substantial opportunities for further

exploration and integration into mainstream NRM research.

The geographical and thematic distribution of research also provides important insights into global knowledge production. The presence of country-specific keywords such as China, India, and the United States indicates that research output is concentrated in regions experiencing significant environmental pressures and rapid economic development. This suggests that NRM research is strongly influenced by regional challenges, such as resource scarcity, pollution, and climate vulnerability. At the same time, it highlights the need for more inclusive and globally representative research, particularly from underrepresented regions that face unique environmental issues but may lack sufficient academic visibility.

This study underscores the ongoing transformation of NRM research from a conservation-focused discipline into a more integrated and innovation-driven field. While traditional themes remain dominant, emerging topics related to digital technologies, sustainability transitions, and interdisciplinary approaches are gradually reshaping the research landscape. Future studies should focus on bridging the gap between established ecological frameworks and emerging technological solutions, as well as enhancing collaboration across disciplines and regions.

4. CONCLUSION

This study provides a comprehensive bibliometric mapping of natural resources management (NRM) research from 2000 to 2026, revealing the field's evolution from a conservation-centered discipline toward a more integrated, interdisciplinary, and technology-driven domain. The findings highlight that while core themes such as environmental protection, biodiversity, and ecosystem sustainability remain dominant, there is a clear emergence of new research fronts related to climate adaptation, digital technologies, and sustainable resource governance. The integration of approaches such as artificial intelligence, remote sensing, and renewable energy indicates a shift toward more data-driven and innovative solutions in managing natural resources. However, the relatively lower concentration of these emerging themes suggests that further research is needed to fully develop and integrate them into mainstream discourse.

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