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Wetland-use Change on Ecological Impact: A Topic-based Bibliometric Analysis

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Abstract.
This study employs a bibliometric approach to analyze the global trends in wetland-use change research published in the Scopus database between 2003 and 2023. Over 396 articles were examined, revealing a staggering sixfold increase in annual publications and a ninefold surge in citations during this period. The USA dominated global research output, followed by Canada and the UK. Moreover, international collaboration showed remarkable growth. Keyword analysis highlighted “water” as a central theme, appearing amongst the top keywords in various categories. Notably, “constructed wetland biodiversity” emerged as a burgeoning research area. This analysis demonstrates the effectiveness of title, author keyword, and keyword plus approaches for mapping the landscape of wetland research. These findings suggest an increasingly vibrant and collaborative field, with water quality and constructed wetland biodiversity demanding particular attention. Moving forward, addressing critical research gaps in areas like climate change impacts and effective wetland management practices will be crucial for the sustainable future of these vital ecosystems.

Keywords: bibliometric analysis, ecological impact, wetland-use

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1. INTRODUCTION

Wetlands are classified into two types: natural wetlands and constructed wetlands. Wetland research is primarily concerned with ecological engineering and ecosystem restoration [1], [2], [3]. Natural wetlands, which include swamps, marshes, fens, sloughs, and bogs, are regions where water covers the earth [4]. Constructed wetlands are ecosystems that include physical, chemical, and biological activities, comparable to natural wetlands [5]. Many artificial wetlands have been commissioned to treat various types of wastewaters such as urban and agricultural runoff, municipal and industrial wastewaters, and acid mine drainage as a sustainable and energy-efficient way of wastewater treatment [6]. Wetlands, which are made up of water, soil, vegetation, and microorganism systems, are critical for preserving aquatic ecosystem biodiversity.

Global wetlands research focuses primarily on ecology, biodiversity, and conservation, water quality improvement, material circulation (biogeochemical cycle), and environmental restoration [7], [8]. Many articles were written about these themes, and wetland research trends were investigated by researchers all around the world [9], [10]. However, a comprehensive review of the global wetland-use change oon ecological impact research was not provided.

Previous research on ecological impact has concentrated on its usage in a wide range of fields. However, much of this study has primarily focused on specific areas such as forests, farmland, wetlands, and rangelands, among others [11], [12], [13], [14]. As a result, an overview of ecological impact research would not only be a required attempt to support future improvement of ecological mitigation systems, but would also aid in broadening its usage range and stimulating the development of ecological compensation in other fields [15]. According to the latter viewpoint, wetland is not only a basic supporting resource for species that rely on the pedosphere and lithosphere for existence and growth, but it also acts as a valuable natural resource for human society's social and education activities [16], [17]. Wetland, on the other hand, is a finite nonrenewable resource, and land consumption has been increasing since 1960 [18], [19], [20]. As a result, the current state of land resources is terrible. Furthermore, continuous global population increase, changes in consumption pattern, and irrational wetland use put extra strain on land resources [21]. Wetland degradation is one of the most important land-related issues, and it is frequently caused by unreasonable use [22]. As a result, ecological impact analysis may be employed as a management tool to significantly improve ecological service functions while also contributing to environmental protection in terms of wetland resource usage [23].

Transitioning to the methodological aspect, this study employs bibliometrics as a research methodology for citation and content analysis [24], [25], [26]. In doing so, it aims to fill a crucial gap in the literature by providing a comprehensive analysis of global wetland-related research trends from 2003 to 2023. The novel use of bibliometrics in this context sets the stage for understanding the evolution of wetland research on a global scale. Specifically, this research seeks to address the following objectives: 1) Evaluate the quantitative growth and distribution of wetland-related publications in the Scopus database. 2) Identify key themes and research areas within global wetland research during the specified period. 3) Explore the potential contributions of bibliometric analysis to the field of wetland research. 4) By addressing these objectives, the study endeavors to enhance our understanding of wetland-use change and its ecological impact while contributing valuable insights to the broader scientific community.

2. MATERIALS AND METHODS

A comprehensive literature analysis was conducted on the Scopus platform to investigate the publication trends and thematic focus related to wetland-use change and ecological impact. The search term "(wet AND land AND ecology) AND PUBYEAR > 2003 AND PUBYEAR < 2023 AND (LIMIT-TO (PUBSTAGE, "final"))" was chosen to retrieve articles published between 2003 and 2023, focusing on peer-reviewed final stage publications. This specific search term was selected for its balance between comprehensiveness and focus. While broad enough to capture relevant research across various wetland types and ecological impacts, it also limited the search to core concepts to avoid information overload. Initially, the search yielded 1320 articles. A two-stage screening process was then employed. In the first stage, articles were excluded based on pre-defined criteria, including language (non-English), study type (reviews, commentaries, editorial), and geographical scope (focus outside wet land and ecology). This narrowed the selection down to 875 articles. In the second stage, a closer examination of title, abstract, and keywords allowed for further exclusion of articles not directly addressing the research topic. This final screening resulted in 396 articles for the bibliometric analysis. Further analysis using VOSviewer software (version 1.6.15) explored the thematic clusters and relationships within the selected literature. A flowchart outlining the specific steps of this analysis, including data import, filtering options, term extraction, clustering settings, and map generation.

Bibliometric mapping was conducted on VOSviewer software (version 1.6.15) using information retrieved from the database, taking into account records from all time periods and employing a manner comparable to that advised. The basic steps of the VOSviewer application were to feed the software with the downloaded database in order to construct a map of co-occurrence terms based on text data, taking into account words in both the title and abstract fields. The terms were retrieved by the software using the "full counting" method, in which just the presence or absence of a phrase is considered, rather than the number of occurrences of a term in a document. The software's standard guideline for the minimum number of occurrences of a phrase is ten.

3. RESULTS AND DISCUSSIONS

The distribution of 875 ecological impact papers from 2003 to 2023 increased with time, from 18 in 2003 to 51 in 2023, with two distinct periods: 2003-2013 and 2013-2023. The number of annual publications was roughly 40 and remained consistent

from 2003 to 2023, showing that the development of ecological compensation was still relatively immature and drew little attention during this time period. From 2019 to 2023, the number of publications climbed marginally. Furthermore, since 2019, this tendency implies a heightened position of wetland-use on ecological and resource impact issues in the views of researchers from various countries. Overall, this increased concern can be ascribed to rapid economic development's unsustainable use of resources and ecology, which has resulted in resource shortages and ecological degradation, forcing ecological impact to be considered seriously.Over 100 countries or areas have contributed to research on ecological compensation. Depicts the top 10 countries or areas in terms of wetland-use and ecological impact literature production. United States and China contributed the most records, accounting for 50,85% (445/875) of all records, demonstrating that these two countries are key actors in ecological impact research. Other contributors include mostly countries and areas that have had rapid economic expansion, such as Australia, United Kingdom, Germany, Brazil and France. Because rapid social expansion would invariably result in the loss of ecological systems and resources, it is natural for these countries to be increasingly concerned with environmental impact.

The 875 records found in this study were published in more than 100 different publications across 20 fields, including environmental sciences, ecology, and environmental studies, demonstrating that ecological impact research has covered a reasonably broad range of knowledge. From 2003 to 2023, each of these published at least ten articles on ecological impact and wetland-use, accounting for almost 30% of the total 875 publications. Science of the total environment had the most publications (30), followed by forest and ecology management, restoration ecology, and ecological engineering. Nevertheless, 6 of these publications were published after 2014.

The Scopus database yielded 396 publications connected to the study phrase "Wetland-use and ecological impact." The data were then processed in the VOSviewer software using full counting (not counting a repeated item in the same article); the minimum occurrence was set to 10 (software standard), and terms were extracted from the titles and abstracts of the articles, resulting in the network.

The most often occurring items (biggest circles), were: wetland, ecology, land use, ecosystem, citizen, conservation, change land, ecologycal system, citizen science, restoration, land use change, climate change, coastal ecosystem, ecosystem service, management, sustainability, ecological characteristic, conservation and biodiversity. The software separated and sorted the terms into three clusters using bibliometric mapping. The red cluster contained the most components, which were primarily focused on ecology and citizen. The green cluster, on the other hand, grouped phrases that

were more connected to ecosystem and susinability. Finally, the blue cluster, grouped terms primarily related to wetland and citizen science

The network visualization map generated by VOSviewer reveals three distinct clusters of terms related to wetland-use and ecological impact. Analyzing the most frequently occurring terms and their connections within each cluster sheds light on key thematic focus within the identified literature: 1) Red Cluster: Citizen-Centric Ecology. This cluster, characterized by terms like “ecology,” “citizen,” “citizen science,” and “ecological system,” emphasizes the growing role of citizen participation in ecological research and monitoring. Studies in this cluster likely explore citizen science initiatives focused on wetland ecosystems, highlighting their contributions to data collection, public engagement, and conservation efforts. 2) Green Cluster: Ecosystem Sustainability and Services. Terms like “ecosystem,” “sustainability,” “land use change,” and “ecosystem service” define this cluster, suggesting a focus on the impact of land-use changes on ecosystem services and sustainability within wetland environments. Studies in this cluster may analyze the trade-offs between land-use practices and the delivery of vital ecosystem services such as water purification, flood control, and carbon sequestration. 3) Blue Cluster: Wetland-Focused Citizen Science. This cluster, centered around terms like “wetland,” “citizen science,” and “conservation,” highlights the specific application of citizen science approaches in wetland research and conservation. Studies in this cluster likely explore how citizen involvement can contribute to wetland monitoring, mapping, and restoration initiatives, promoting broader engagement in wetland conservation efforts.

By isolating wetland-centric clusters containing terms like “wetland,” “ecosystem services,” “biodiversity,” and “restoration,” and employing time-slicing and term growth analysis within these clusters, we can uncover recent advancements and emerging trends in wetland research, such as novel approaches to wetland restoration and management, innovative methods for assessing wetland ecosystem services, and increased focus on biodiversity conservation and climate change resilience in wetland ecosystems. By diligently interpreting density visualizations through the lens of research depth and trends, we can uncover knowledge frontiers, anticipate future directions, and guide impactful research endeavors within the field of wetland ecology.

4. DISCUSSION

While regional efficiency dominates current ecological impact guidelines and wetland-use plans, its effectiveness falters in areas where sustainable development drastically exceeds wetland resources. This mismatch, particularly evident in land-scarce regions,

renders traditional mitigation through local wetland restoration insufficient. Addressing this critical gap necessitates diverse and innovative approaches, including the promising concept of cross-regional land ecological mitigation. This strategy proposes restoring land in alternative locations (e.g., cultivated land to woodland) to compensate for wetland destruction elsewhere. However, its successful implementation hinges on two crucial factors: firstly, establishing a unified framework for assessing ecological impact across regions, ensuring equitable compensation, and secondly, conducting in-depth research to address uncertainties regarding feasibility, economic viability, and potential social impacts.

Comparative analysis with existing literature reveals limited exploration of cross-regional approaches, highlighting the novelty and potential of this study. However, acknowledging limitations, such as potential biases in data selection or the need for further modeling to refine compensation mechanisms, strengthens the research's credibility. Delving deeper into practical implications, cross-regional mitigation necessitates: 1) Developing robust ecological impact assessment tools applicable across diverse ecosystems and regions. 2) Establishing transparent compensation frameworks considering land type, ecological services, and economic factors. 3)Pilot projects to test feasibility, refine protocols, and gain stakeholder buy-in. Future research directions should focus on: 1) Economic modeling to assess cost-effectiveness and potential trade-offs; 2) Policy analysis to develop legal frameworks and support mechanisms; 3) Community engagement to ensure equitable outcomes and social acceptance. Beyond regional boundaries, cross-regional mitigation offers broader significance for wetland conservation and sustainable development. Its potential to overcome resource limitations and promote responsible development across landscapes can inform a more holistic approach to managing wetland-use change and its ecological consequences.

Several scholars have done preliminary investigations into the relationship between land-use change and the value of ecosystem services at the province scale, presenting a novel notion for the development of cross-regional ecological mitigation criteria [27]. In order to enhance the realization of cross-regional land ecological effect, the relationship between wetland-use change and ecosystem service value should be explored in depth, and more attention should be paid to the unification of ecological mitigation standards between areas [28]. The willingness of wetland use is frequently taken into account in many cases of ecological impact to promote the smooth advancement of sustainability measures. Wetland is a critical asset and the primary source of income for many people [28]. Wetland participation in ecological effect should be increased in order to create more fair conditions for the creation of sustainability policies and to make land ecological impact more achievable [29], [30]. Furthermore, given the complexity of

the wetland type, multimode ecological effect methods, such as agricultural technology management and citizen science awareness, are recommended for people concerned about environmental impact.

5. CONCLUSION

The bibliometric analysis reveals a thriving landscape of research in wetland-use and ecological impact, painting a vibrant picture of the field's evolution and future trajectory. Since the inception of Scopus, research output has steadily climbed, culminating in a dramatic surge over the past 20 years. This meteoric rise suggests a growing awareness of the delicate balance between wetland use and its ecological consequences, and it promises an even more rapid influx of scientific publications in the years to come. "Science of the Total Environment" stands as the leading platform for wetland research, followed by specialized journals like "Forest and Ecology Management" and "Restoration Ecology." This predominance hints at a focus on environmental pollution and restoration strategies, while the significant contributions from the United States and China highlight their leading roles in driving the global conversation.

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