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Bibliometric Analysis of Funding Aspect in the Domain of Marine Protected Area

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ABSTRACT
This paper conducts a comprehensive literature review on the aspect of funding in the management of Marine Protected Areas (MPAs) using bibliometric analysis through the VOSviewer software. Indonesia, as a country with high biodiversity, heavily relies on marine ecosystems, making effective MPA management reliant on adequate funding for monitoring, surveillance, and habitat rehabilitation. International publication data were collected from Scopus (2000-2024) using the keywords "Marine + protected + area + finance", yielding 47 articles analyzed to map research trends and relationships among factors. The analysis results show an increase in studies since 2017, focusing on MPA management, sustainability, environmental protection, biodiversity, and financial aspects. Network visualization reveals strong interconnections between funding, governance, and community participation in MPA management. In conclusion, funding is a critical aspect that still requires further development through additional research.

Keywords: Marine Protected Area, Sustainable Financing, VOSviewer

INTRODUCTION

Indonesia, renowned for its extraordinary biodiversity, depends heavily on its marine ecosystems for both food security and economic prosperity. Marine Protected Areas (MPAs) serve as vital sanctuaries for preserving biodiversity, providing refuge for endangered species, and safeguarding critical habitats. These areas play a pivotal role in maintaining ecosystem health, enhancing fisheries productivity, and mitigating the adverse effects of climate change. The archipelago's diverse marine environments including coral reefs, mangroves, and seagrass beds face escalating threats from human activities such as overfishing, pollution, and climate change. These pressures necessitate robust management strategies to ensure the sustainability of the extensive network of MPAs across Indonesia (Dee Boersma and Parrish, 1999). Effective conservation area management is essential not only to protect these ecosystems but also to improve the livelihoods of local communities through sustainable resource utilization (Samosir *et al*. 2024). Among the critical factors underpinning successful management is adequate funding, which remains a significant challenge. Insufficient financial resources often hinder the implementation of effective conservation policies and programs, limiting the capacity to monitor, enforce, and restore marine environments.

Funding is indispensable for supporting essential activities such as supervision, monitoring, and enforcement within MPAs (Tarigan *et al*. 2019). Moreover, it facilitates the rehabilitation of habitats damaged by anthropogenic or natural causes and supports the expansion and development of marine protected areas. Martawardaya and Adha (2023) emphasize that adequate funding is crucial for optimal conservation management.

Recent research highlights the integration of economic approaches into MPA management, recognizing funding as a core component (Costanza *et al*. 2014). This study aims to provide a comprehensive literature review on the role of funding in MPA management by employing VOSviewer bibliometric analysis software. This tool maps the current research landscape, identifies emerging trends, and analyzes the interrelationships among factors influencing

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funding in MPA management. The novelty of this work lies in quantifying the development and trends of international publications on marine protected area management and funding aspects through bibliometric methods.

Literature Review

Marine Conservation

Marine conservation is a vital effort to sustain aquatic ecosystems, encompassing seas, rivers, lakes, and wetlands. Its objectives include protecting biodiversity, maintaining water quality, and ensuring the sustainable use of aquatic resources. Conservation strategies involve habitat protection, water quality management, and pollution control (Angela 2023). Community-based approaches in marine conservation enhance program effectiveness by involving local populations in resource management. Environmental education is crucial to raising public awareness about the importance of preserving aquatic ecosystems (Mahfudin *et al*. 2023). Collaboration among government, communities, and the private sector is essential to achieving sustainable conservation goals. Given the increasing pressures on aquatic resources from climate change and human activities, it is imperative to develop comprehensive, evidence-based policies to support effective marine conservation (Aminuddin and Burhanuddin, 2023).

Funding in Conservation Management

Funding is a critical aspect of conservation management, especially in the context of marine conservation. The success of conservation programs heavily depends on the availability of adequate financial resources to support activities such as research, monitoring, habitat management, and community empowerment. Without sufficient financial backing, conservation efforts may be hindered, and the goals of protecting aquatic ecosystems may not be achieved (Soemodinoto *et al*. 2021). Funding sources for conservation areas can come from various stakeholders, including government budgets such as the State Budget (APBN), Regional Budgets (APBD), international agencies, the private sector, and philanthropy. Diversifying funding sources is key to effective conservation management (Tarigan *et al*. 2019). Another emerging funding source is Payments for Ecosystem Services (PES), which incentivizes communities to conserve natural resources. PES is an increasingly popular approach where beneficiaries of ecosystem services, such as companies or individuals, pay those who maintain the ecosystems. This mechanism not only supports the financial sustainability of conservation programs but also enhances community participation in managing aquatic resources (Solihin *et al*. 2019).

Proper and transparent budget allocation is also crucial in supporting conservation programs (Talantan *et al*. 2022). Sustainable funding not only supports conservation activities but also contributes to local capacity building and community empowerment. Collaboration among government, private sector, and local communities is vital in creating sustainable funding models. The involvement of multiple stakeholders enables more effective and responsive management of conservation areas tailored to local needs (Aulia *et al*. 2021).

Literatur Review and VOSviewer

A literature review is a systematic process of identifying, evaluating, and synthesizing relevant literature on a research topic. It begins with formulating clear and focused research questions. The review involves gathering references from scientific journals and other scholarly sources to provide a theoretical foundation for new research (Perry and Hammond, 2002). Typically, a literature review includes sections that explain theories, findings, and materials pertinent to the research, forming the basis for the study. Conducting a thorough literature review is essential for developing a robust framework to address research problems. It involves searching for data relevant to the topic, which is critical for obtaining pertinent information (Ridwan *et al*. 2021).

VOSviewer is a bibliometric analysis software designed to assist in the literature review process by visualizing and analyzing bibliometric data. It can process large datasets of scientific publications and generate network visualizations that illustrate relationships among authors, institutions, and keywords. These visualizations help identify research trends, collaborations, and emerging topics (Effendy *et al*. 2021). Users can interact with the maps by zooming, scrolling, and browsing. VOSviewer's outputs include identifying research trends, analyzing collaborations, and assessing the performance of researchers or institutions. It visualizes keyword networks that reveal main themes and sub-themes within a research field (Rofika *et al*. 2023).

MATERIAL AND METHOD

Data Collection

Data for this study were collected from the Scopus database on February 3, 2025, using the search keywords "Marine + protected + area + finance" covering the period from 2000 to 2024. To ensure relevance, subject area restrictions were applied, including environmental science, agricultural and biological sciences, social sciences, earth and planetary sciences, and economics, econometrics, and finance. These restrictions aimed to focus the search on publications discussing financial aspects of marine protected area management. The data collection was further refined by selecting only final articles, journal articles, and publications in English to maintain quality and consistency.

Data Analysis

The collected data were analyzed using bibliometric methods to identify literature indexed in Scopus related to funding in conservation area management. Visualization of bibliometric data was performed using VOSviewer software, focusing on co-occurrence analysis of keywords. The analysis unit was keywords, using full counting methods, and including keywords that appeared at least twice. The bibliometric visualization aimed to map relationships between topics and identify clusters of related research themes, providing insights into the structure and trends within the field.

The method is explained briefly and conveyed properly. The sub-chapters are arranged in sequence starting from the time and place/location, tools and materials, research methods, and data analysis used. Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described. Please describe whether the study is experimental or exploratory. Name the number of samples and give courtesy to whom you obtain the sample. State seasonal variation of the habitat (if applicable) or date of sampling. Sample of animal should be collected in conformation to standard ethics and with written informed consent.

RESULT AND DISCUSSION

The bibliometric analysis using VOSviewer yielded a mapping of publication trends and thematic clusters based on the keywords "Marine + protected + area + finance." A total of 47 articles were identified within the 2000–2024 timeframe.

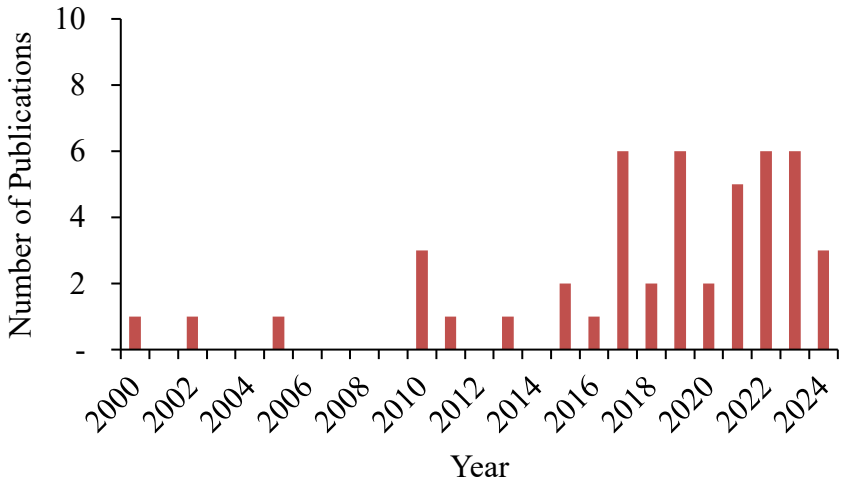

Figure 1. Tren of research activity related to MPA finance (2000-2024)

Table 1. Visualization clusters by color

Cluster	Color	Number of Keywords	Focus Areas
Cluster 1	Red	13	Protected area, marine environment, sustainability, conservation management
Cluster 2	Green	8	Environmental protection, conservation, willingness to pay
Cluster 3	Blue	3	Biodiversity, ecosystem services
Cluster 4	Yellow	3	Finance, governance approaches

Analysis of publication trends revealed a gradual increase in studies on marine protected area funding, with fluctuations each year. Notably, research activity on this topic began to gain momentum around 2017, indicating growing global interest. Publications originated from 35 countries, with the United States leading with 18 related publications.

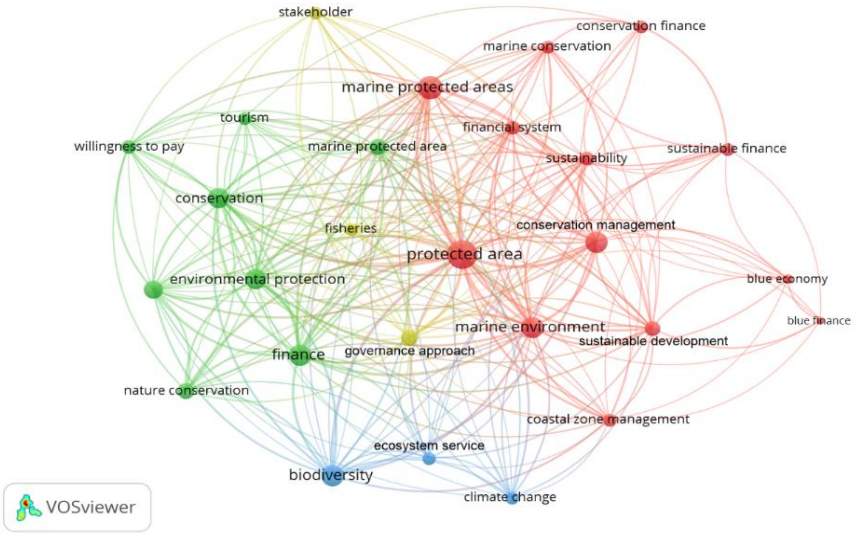

Figure 2. Network Visualization Map based on Keyword

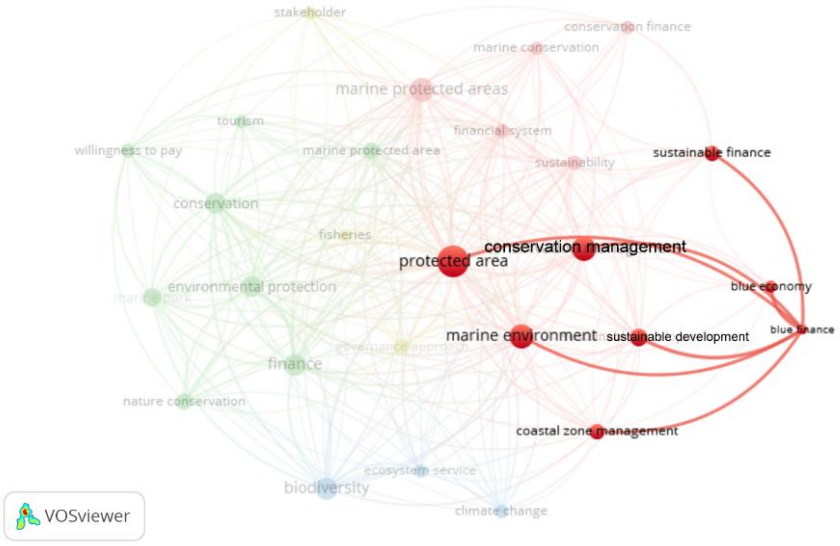

Figure 3. Red cluster keyword network (finance) visualization

The network visualization map, based on keyword co-occurrence, identified four distinct clusters differentiated by color:

The red cluster emphasizes the interconnection between protected area management, sustainability, and conservation management. The green cluster highlights environmental protection and public willingness to financially support conservation efforts.

The blue cluster focuses on biodiversity and ecosystem services, underscoring their importance in conservation. The yellow cluster addresses financial mechanisms and governance strategies critical to conservation success.

The strength of relationships between concepts is depicted by the thickness of connecting lines, indicating frequent co-occurrence in the literature. This visualization underscores that marine protected area management encompasses environmental, financial, governance, and community participation dimensions.

Within the red cluster, focused topics include "sustainable finance," "blue economy," and "blue finance," highlighting the financial and economic aspects of conservation.

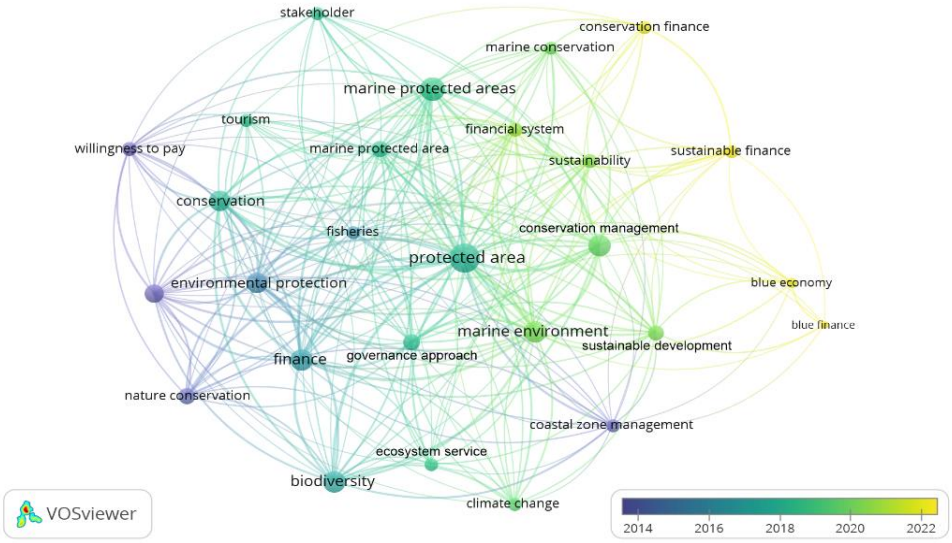

Figure 4. Knowledge transformation of MPA finance

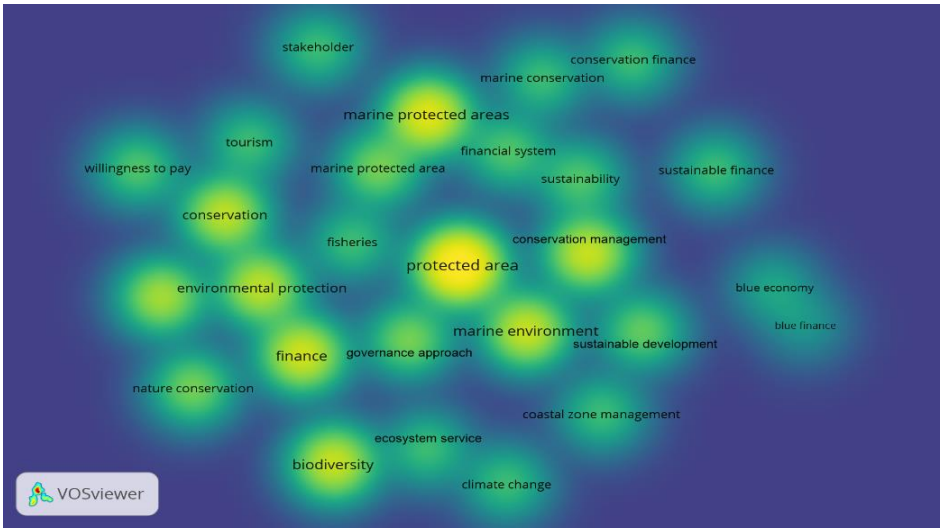

Figure 5. Density visualization map

The overlay visualization map shows publication years associated with research topics, ranging from 2014 to 2022. The dominant publication period is between 2014 and 2020, indicated by purple and green colors. Bright colors denote widely discussed topics, while faded colors suggest less explored areas. The density visualization map illustrates the frequency and relationships of terms. Topics such as "marine protected areas" and "protected areas" exhibit high density, indicating frequent discussion. Terms like "sustainability," "sustainable finance," and "conservation finance" reveal the close linkage between financial mechanisms and conservation efforts. Bright yellow areas indicate topics with extensive research and updates, whereas greenish areas denote less explored subjects.

Funding emerges as a critical topic in marine conservation management, providing long-term opportunities for effective area management. According to the World Wide Fund for Nature (2009), funding management involves not only securing resources but also allocating them efficiently and effectively to optimize conservation outcomes. Research focusing on funding challenges is essential, as financial constraints often impede marine protected area management.

CONCLUSION

The bibliometric analysis conducted reveals that research on funding for aquatic conservation management from 2000 to 2024 remains relatively limited. However, there has been a noticeable increase in studies since 2017, focusing on conservation management, sustainability, environmental protection, biodiversity, and financial and governance aspects. Although research on MPA funding spans 35 countries, the volume of publications is still modest, indicating a need for expanded investigation to address

funding challenges and improve financial resource allocation. Given the pivotal role of funding in supporting effective and sustainable conservation management, further research and policy attention are warranted to enhance the financial sustainability of marine protected areas. Since blue financing development is still relatively new, so studies related to this topic still need to be developed. The gap that raises finance studies at the global level in Indonesia is still small, only 2.1% of global knowledge.

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