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# Bibliometric Analysis of Coral Reef Conservation and Mooring Buoy Applications in Sustainable Marine Tourism

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***Abstract*— Ship mooring at coral reef slope is a high risk for Indonesian coral reefs, particularly in tourist based coastal environment. Mooring buoy technology is a well-established component of offshore engineering but has not yet been fully adapted to shallow coral reef ecosystems. This bibliometric analysis of 2015-2024 publications was performed using Lens.org and VOSviewer in search of research trends and knowledge gaps. The study finds six main research clusters, including: environmental management, tourism, and technical aspects; conservation, ecosystem behaviour, and protected areas; sustainable development and threats; coral reefs and ecosystem resilience; fisheries and the deep sea; and sea monitoring and conditions. While coral reef conservation research also has good representation, the following are important gaps identified in this study: mooring technology is very isolated in its own network with little apparent influence on conservation or oceanographic fields. This reflects two major gaps: mooring technology are not associated with conservation objectives, and mooring designs have not been adapted to Indonesia's unique oceanographic conditions. This research demonstrates that developing mooring buoys suitable for Indonesian shallow waters represents a strategic opportunity to bridge engineering with practical conservation. Future research should focus on three areas: site-specific hydrodynamic characterization at marine tourism destinations; numerical simulation of adaptive mooring designs; and community-based implementation frameworks for long term sustainability.**

*Keywords*—bibliometric analysis, coral reefs, mooring buoy, sustainable tourism, VOSviewer, coral reef conservation.

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## I. INTRODUCTION

Indonesia, the biggest archipelago in the world, is located at the center of the coral triangle. Therefore, marine tourism is becoming one of the main focuses in the development of the national blue economy. Based on research showing a drastic increase in global marine recreation and ship traffic [1], [2], it can be concluded that physical damage to coral reefs also has the potential to increase along with this trend [3]. Physical damage caused by poorly managed ship anchoring activities is a form of significant damage that is frequently ignored. Theoretically, mooring buoy technology has long been recognized as an engineering solution to mitigate this impact. The installation of mooring buoys is an effective method for mitigating damage to coral reef ecosystems [4]. The lack of sufficient mooring infrastructure compels ship operators to anchor on coral reef slopes. Consequently, laws are necessary mandating that ships operating in coral reef areas use accessible mooring buoys [5], [6], [7]. The collaboration between mooring buoys and ecologically informed site selection provides a practical management framework for mitigating ship impacts and preventing harmful anchoring practices on sensitive coral habitats [4], [8]. In addition to environmental advantages, the mooring buoy system generates economic prospects for the local community through mooring buoy usage fees [9].

Factual incidents in Labuan Bajo, one of Indonesia's main tourist destinations, confirm the significance and urgency of this issue. The anchoring activities of tourist ships directly caused significant coral reef damage in the waters of Sebayur Kecil in October 2025. This incident triggered a strong response from the Port Authority and professional associations while also highlighting significant weaknesses in the management of anchorage space within the sensitive ecosystem area. This case highlights the urgent need for technical and regulatory interventions, such as the implementation of a managed mooring buoy system, to replace conventional mooring methods that have been destructive and unsustainable [10].

Although the effectiveness and reliability of mooring buoy technology in offshore engineering have been proven, its implementation in Indonesia, especially for tourism activities in shallow tropical coral reef areas,

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remains limited. The main obstacles to the adoption of this technology are several interconnected challenges. First, there is a knowledge integration gap, where mooring system designs in offshore engineering have not been fully connected with the literature on conservation and tourism management. These engineering solutions have not been explicitly integrated with the objectives of coral reef conservation and sustainable tourism management. Second, there is a gap in implementation, as the mooring buoy designs developed for deep offshore waters have not yet been adapted to tropical tourist areas in shallow waters with different oceanographic conditions. Finally, there is a specification gap in existing mooring buoy designs that have not been adapted to the unique and challenging oceanographic conditions of Indonesia. This scenario includes monsoon wave patterns, tropical cyclone risk, and highly diverse bathymetric variations from shallow diving zones to deep sea channels. This conclusion underpins the recommendation to develop a mooring buoy design that is more adaptive and responsive to the environmental characteristics of the region.

Bibliometric analysis is a methodical approach to determining knowledge structures, research gaps, and research trends in a topic. Using sophisticated tools, such as VOSviewer, to map scientific publication networks, researchers can: visualize the connections between concepts and research topics; identify new and established research areas; and reveal where knowledge integration gaps occur with quantitative precision [11].

This research uses bibliometric analysis of Lens.org-sourced publications from 2015 to 2024 to perform three critical functions. These functions include mapping current research developments, visualizing knowledge gaps between engineering and conservation fields, and formulating a scientific basis for developing specific technical solutions. Based on this analysis, the main objective of the research is to identify research gaps at the intersection of engineering solutions and environmental conservation. Additionally, this study aims to establish a framework for future research focusing on the practical design of mooring buoys in shallow waters, numerical simulations based on Indonesian sea conditions, and community implementation strategies.

The significance of this research lies in proving that Indonesia's separation between offshore engineering technology and conservation needs is a real problem. This issue is not just a theoretical concern but a fact evident from the field of environmental damage incidents. These challenges can be addressed through an integrated approach that combines oceanographic science, ocean engineering, and conservation principles. This study makes a strategic contribution to addressing the urgent need to conserve the environment while supporting the economic sustainability of national tourism.

## II. METHOD

This study adopts a descriptive quantitative method with bibliometric analysis, enabling an in depth exploration of existing scientific literature in two relatively separate domains: offshore engineering and coral reef conservation management. This methodology is designed to map the intellectual structure within the topic, identify current research trends, and detect knowledge gaps that may not have been addressed in the existing literature. Therefore, this method not only gives researchers a tool to verify hypotheses about the separation between the two domains but also provides new insights that can unlock more cross-disciplinary collaboration potential. The research procedures were systematically conducted using three interconnected main phases: data collection and search strategies, bibliometric analysis and visualization, and thematic cluster identification.

### *A. Data Sources and Search Strategy*

Bibliometric data were collected from the Lens.org database. Lens.org was chosen because of its extensive coverage of multidisciplinary scientific literature, including peer-reviewed journals, conference proceedings, and technical reports, as well as its ability to provide open citation metadata. Data searches are limited to the publication period from 2015 to 2024 to cover a decade-long timeframe, reflecting technological advancements and current issues.

The search strategy uses Boolean operators (AND, OR) to capture the intersection between the two main domains of study:

1) Mooring technology and floating structures (e.g., "mooring", "anchoring", "mooring buoy"); and
2) Coral reef conservation (e.g., "coral reef", "conservation").

The search terms were formulated to ensure that the selected literature relates to the interactions among ship activities, marine structures, and highly sensitive ecosystems. Publications are filtered based on topic relevance and bibliographic information availability. The data that passed the selection was then exported in RIS format, which contains complete metadata (author, title, year, abstract, and keywords) for further processing.

### *B. Bibliometric Analysis and Visualization*

Data analysis was described using VOSviewer software to construct and visualize bibliometric networks. VOSviewer was chosen for its excellence in generating comprehensive visual maps of concepts' relationships [11]. Three specific analysis techniques were applied to answer the following research objectives:

1) Keyword co-occurrence analysis: This technique is theoretically used to map the cognitive structure of the research and identify the main thematic clusters [12]. In its implementation, each keyword is extracted from the publication's title, abstract, and list of keywords. Co-occurrence frequencies are calculated and visualized in the form of a node-link network, where node size indicates frequency of occurrence and line thickness (edge) indicates the strength of the relationship.
2) Network analysis: This analysis was conducted using the VOSviewer algorithm, where the distance between nodes represents the strength of association;

the position of nodes in peripheral areas indicates topic isolation or a lack of knowledge integration [11]. This analysis measures the distance and strength of the relationship between technical keywords (such as mooring buoy) and conservation keywords. This is crucial for proving the "knowledge integration gap" hypothesis, where technical solutions are believed to be on the periphery of the conservation research network.

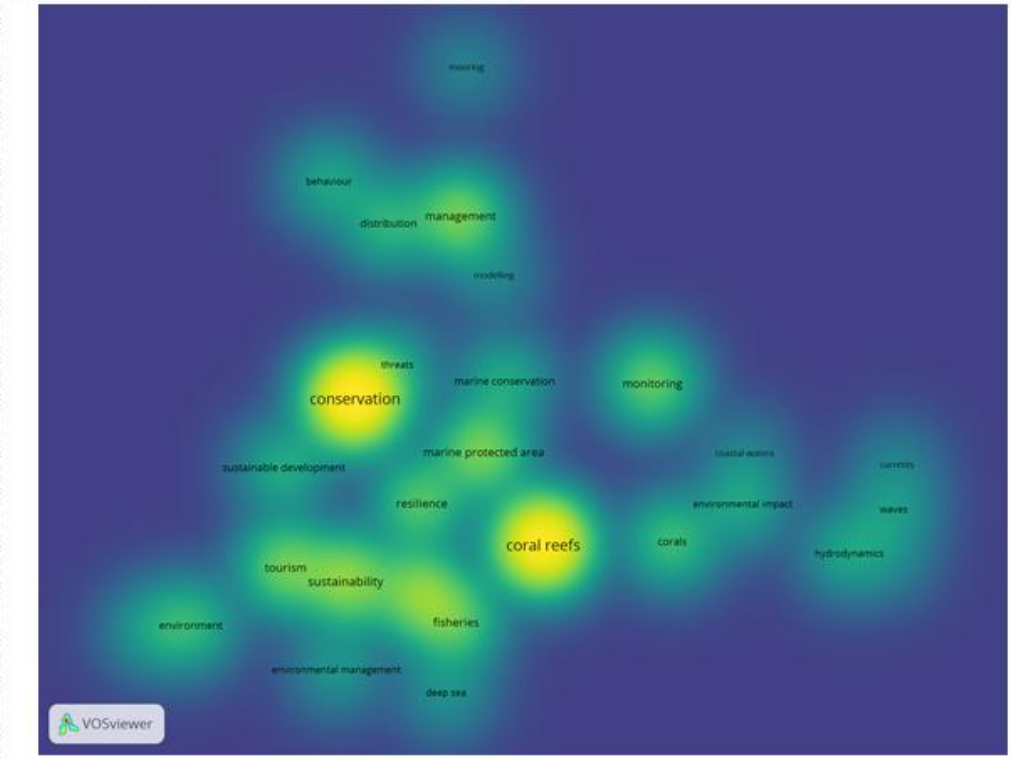


**Figure 1.** Density visualization in VOSviewer

3) Density visualization: This technique is used to detect topic saturation, where areas with low density are interpreted as potential research gaps for exploration. This visualization uses a heat map [13]. This is to demonstrate the concentration of research within a multidimensional topic space, helping to identify hot spots (dense areas) and peripheral areas (minimum research areas). Areas with low density but high relevance will be interpreted as strategic opportunities, particularly for developing Indonesian-specific mooring buoys.

*C. Thematic Cluster Identification*

Cluster thematic analysis is performed using the community detection algorithm available in VOSviewer to identify the existing research network structure. This study classified existing topics into three main categories by considering the relative position of keywords: (1) established topics, (2) protected topics, and (3) areas showing a lack of integration between engineering and conservation fields. This knowledge gap was then further explained to explore three key issues: first, the knowledge gap hindering the integration between mooring design and the implementation of conservation efforts; second, the synchronization of implementation occurring in deep waters and waters with different technical and ecosystem challenges; and third, the mixed specifications related to adapting mooring designs to Indonesia's oceanographic characteristics. The results of this analysis are highly relevant for providing a more comprehensive picture of the challenges faced in implementing technical solutions in the field and for ensuring that this research remains closely connected to real-world practical issues.

## III. Results and Discussion

This study aims to map existing research trends and identify knowledge gaps regarding coral reef conservation, mooring buoy technology, and sustainable marine tourism. Using the bibliometric analysis method with VOSviewer, this study reveals six major thematic clusters that reflect the evolving academic attention surrounding these issues. Two complementary visualization images illustrate how research concepts are connected and evolving within the scientific literature. The density visualization presented in Figure 1 effectively demonstrates the concentration and saturation of research topics across different thematic areas, revealing research hotspots and peripheral zones. Meanwhile, the keyword co-occurrence networks displayed in Figure 2 provide detailed illustrations of the relationships and connectivity strength between specific topics, enabling the identification of how different research domains interact and integrate.

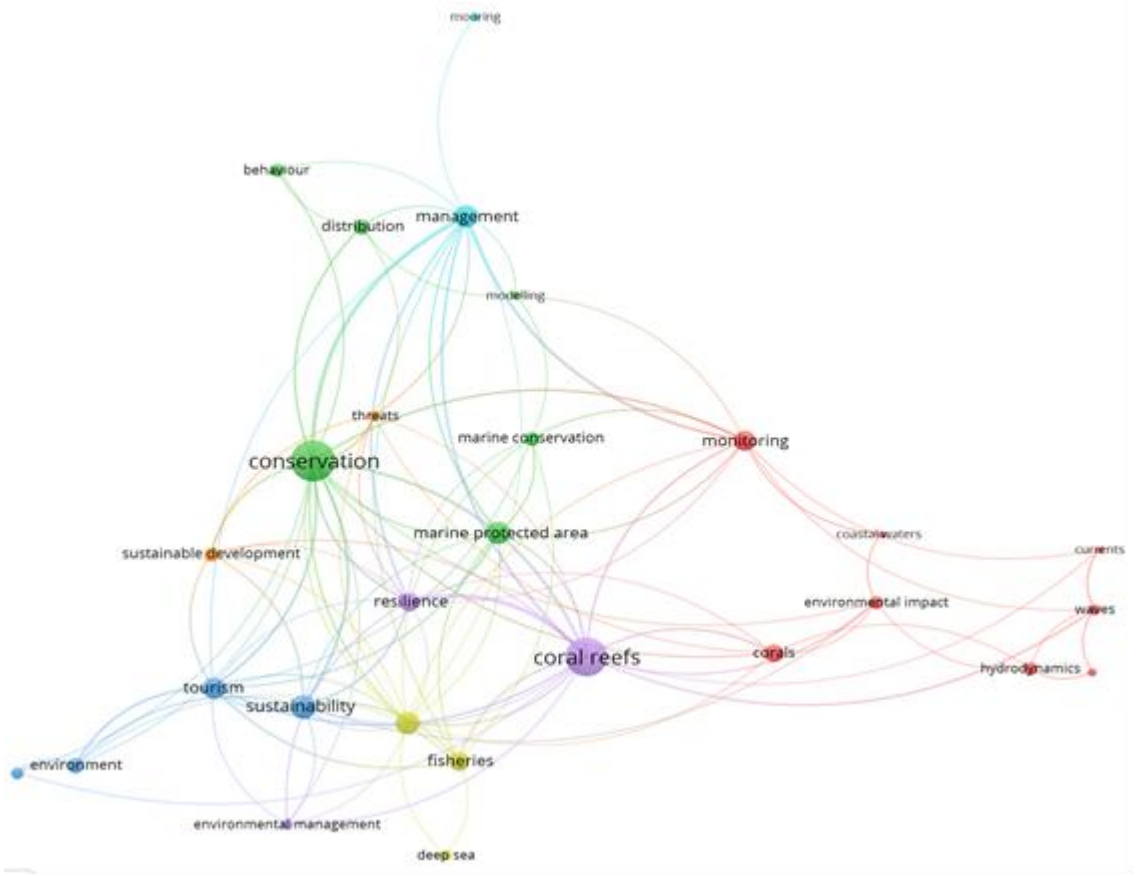


**Figure 2.** Network visualization of keyword co-occurrence in VOSviewer

*A. Identification of Thematic Clusters and Knowledge Network Structure*

Keyword co-occurrence Keyword co-occurrence analysis using VOSviewer reveals a complex bibliometric network structure with an uneven research distribution. The density visualization shows a high concentration of research around three overlapping main areas: "conservation", "coral reefs", and "sustainability", reflecting the central topics that have been the focus of the global research community. The area with the highest density (shown in bright yellow) is centered around the keywords "coral reefs" and "conservation", representing a very mature research foundation in the field of coral reef conservation. Keywords closely associated with this core include "marine conservation", "marine protected area", "sustainable development", "threats", "resilience", "tourism", "sustainability", "fisheries", "environmental management", and "coral reefs". The strong presence of "tourism" and "sustainability" in high-density areas indicates that an integrated understanding of the relationship between coral reef protection and sustainable development has been developed in the scientific literature. This is particularly relevant in the context of Indonesia, where coral reefs are a valuable asset not only for the marine ecosystem but also for the marine tourism economy.

Stemming from this central concentration, there is a cluster of keywords indicating expansion toward management and monitoring, with words like "management", "monitoring", "distribution", "behaviour", and "environmental impact" appearing with moderate density. This area reflects the growing research on the practical implementation of operational marine resource conservation and management strategies. The presence of "environmental impact" indicates awareness of the negative effects of human activities on marine ecosystems. The focus on "management" signifies that the scientific literature is increasingly recognizing the importance of active and adaptive management of coral reefs, rather than just passive protection through no-take zones.

On the other hand, a low density area containing words like "coastal waters", "currents", "waves", and "hydrodynamics". This group represents ocean conditions. Although this topic is important for understanding the coral reef environment, its position seems to be somewhat separate from the main conservation topics. This indicates a gap between oceanography (which studies the movement of seawater) and conservation science (which focuses on ecosystem protection). This density visualization reveals a striking gap: the topic of “mooring” (anchoring systems) appears 'isolated' at the very top of the map with extremely thin color density. This position is in stark contrast to the topics of “conservation” and “coral reefs”, which shine brightly in the center as the main research focus, as well as the topics of “tourism” and “sustainability”, which are strongly clustered at the bottom. The significant spatial distance between the “mooring” and this cluster of tourism and sustainability confirms that in the current literature, infrastructure technical solutions have not yet been considered an integral part of conservation strategies. This is a fatal missing link: we talk a lot about

sustainable tourism, but there is minimal research on the technical tools (e.g., moorings) to make it a reality.

*B. Co-occurrence Network Analysis: Topic Connectivity and Isolation*

A more comprehensive overview of the knowledge structure in marine conservation and sustainable tourism literature requires a deeper analysis of the relationships between topics. Compared with density visualization, co-occurrence network visualization offers a more detailed perspective on topic relationships. This map displays nodes connected by lines (edges). The size of the nodes reflects the frequency of keyword occurrences, and the thickness of the lines indicates the strength of the relationship or co-occurrence between two keywords. This analysis reveals highly informative connectivity patterns regarding the structure and integration of knowledge in the scientific literature on marine conservation and sustainable tourism. Six main clusters can be identified in this network based on color grouping based on the VOSviewer clustering algorithm, each with different connectivity characteristics and spatial positions:

a) Cluster 1 (Blue): Environmental Management, Tourism, and Technical Aspects. This blue cluster plays an important role because it connects marine management topics. It contains the following key keywords: "environment", "sustainability", "tourism", "management", and "mooring". This cluster's position is strategic because it unites environmental issues with the economic needs of tourism and its management. The relationships between topics within this group are very close. The presence of the words "sustainability" and "tourism" alongside "management" indicates that researchers agree: tourism must be well managed to protect the environment. The word "environment" here serves as the foundation, meaning that every tourism management decision must always consider environmental conditions. However, there is one unique aspect of the keyword "mooring". Although it falls into this management group, its position on the map appears somewhat isolated, and its connection to other topics is rather weak. This means that although "mooring" is recognized as part of marine management, it is rarely discussed in depth alongside the topic of sustainable tourism. Although this topic is within the group, it is still on the periphery. Overall, this blue cluster indicates that management and tourism topics are already being widely associated with other conservation issues (as evidenced by their connections to other color clusters). However, this integration is not yet perfect because the technical aspects of infrastructure, such as mooring, are often overlooked in the main discussion.
b) Cluster 2 (Green): Conservation, Ecosystem Behaviour, and Protected Areas. This green cluster, located in the upper-left corner of the visualization, focuses on ecological and conservation aspects. This cluster includes the keywords: "conservation", "behaviour", "distribution", "marine protected area", and "marine conservation". The "conservation" node emerges as the largest node in this cluster and one of the largest nodes in the entire network, indicating its extremely high frequency of occurrence in the literature and its position as a central concept in marine research. The internal connectivity of the green cluster is very strong, with thick lines connecting almost all nodes. This indicates that an integrated understanding of the relationship between conservation, ecological dynamics (species behaviour and distribution), marine protected areas, and comprehensive marine conservation strategies has been developed. The presence of "marine protected areas" as an important component of this cluster suggests that marine protected areas are viewed as a key mechanism in coral reef conservation strategies. "Marine conservation" in the green cluster indicates that research has developed a mature and integrated discipline for the protection of marine ecosystems. The keywords "behaviour" and "distribution" refer to the behaviour of marine species and ecological distribution, which are fundamental aspects of conservation strategies and the understanding of how coral reef ecosystem's function, react to disturbances, and can be restored. The dominant position of the green cluster, both spatially and in terms of node size, confirms that the topics of conservation, marine protected areas, and marine ecology are central to academic discussions in the analyzed literature. The strong connectivity of the blue, orange, purple, and yellow clusters indicates that a conservation perspective has become the main framework for integrating various aspects of marine research.
c) Cluster 3 (Orange): Sustainable Development and Threats. The orange cluster in the upper middle contains two main keywords: "sustainable development" and "threats". Although it only contains two topics, the position of this cluster is crucial in the research network. Interestingly, the phrase "sustainable development" here is separate from the word "sustainability" found in the blue cluster. This indicates that sustainable development is considered a broader and more comprehensive concept tha encompasses environmental economic, and social aspects for the long term. Meanwhile, the word "threats" indicates that much research focuses on recognizing the dangers faced by coral reefs, such as climate change or physical damage. Understanding this threat is a mandatory first step before designing the appropriate rescue solution. The position of this cluster acts as a connecting bridge. Economic goals (from the blue cluster) are connected to concrete conservation actions (green cluster) and coral reef protection (purple cluster). This means that the concept of sustainable development and an understanding of threats are the key elements that unify unites these various research topics.
d) Cluster 4 (Purple): Coral Reefs and Ecosystem Resilience. The purple cluster in the middle contains three key topics: "coral reefs", "resilience", and "environmental management". The word "coral reefs" appears as the second largest point after

"conservation", proving that coral reefs are a major focus of this research. The appearance of the word "resilience" in this group indicates that researchers are very concerned about the ability of coral reefs to survive and recover from damage. The close relationship between "coral reefs" and "resilience" indicates that today's primary strategy is to make ecosystems as strong as possible against various pressures, both from human activity and natural changes. Additionally, the presence of "environmental management" here confirms that we cannot simply stand by and wait for nature to heal itself. Active environmental management is needed to keep coral reefs healthy. The strong connection of this cluster with the Green Cluster (Conservation & Protected Areas) and the Orange Cluster (Sustainable Development & Threats) concludes one important thing: coral reefs are priority ecosystems that require comprehensive protection. This means that coral conservation strategies must simultaneously integrate regional conservation efforts (green), an understanding of development threats (orange), and active environmental management (purple).

e) Cluster 5 (Yellow): Fisheries and the Deep Sea. The yellow cluster located in the lower middle section contains two main topics: "deep sea" and "fisheries". Although the deep sea and coral reefs (shallow waters) are two distinct locations, the presence of both topics in one group suggests an interesting connection. Research seems to be starting to link what happens in the deep sea with fisheries management. The word "fisheries" here indicates that fisheries affairs cannot be separated from marine conservation. The health of coral reefs and fish catches are interconnected; healthy coral provides a home for fish, and good fish management keeps the coral sustainable. Meanwhile, the topic of the "deep sea" likely emerged due to the reciprocal relationship between shallow and deep sea ecosystems, or as an alternative fishing area to reduce pressure on coral reefs. This cluster's relationship with the Green Cluster (Conservation) indicates that researchers are aware: managing fisheries is part of protecting coral reefs. However, because this yellow cluster is somewhat on the edge of the map, the topic of fisheries and the deep sea is indeed important, but it is not yet a primary focus in current coral reef conservation literature.

f) Cluster 6 (Red): Sea Monitoring and Conditions. The red cluster on the right side contains technical topics such as "monitoring", "environmental impact", and physical sea conditions like "waves", "currents", and "hydrodynamics". This group focuses on monitoring the environment and understanding the impact of human activities on the ocean. The word "monitoring" appears to be the most important point here. Its position is strategic because it serves as a connecting bridge between the red cluster and all other clusters (green, blue, orange, purple, and yellow). This means that monitoring activities are recognized as a key element connecting ocean conditions with conservation and management efforts. Meanwhile, the topic "environmental impact" indicates a research focus on the negative effects of human activities on ecosystems, such as ship anchoring or tourism. Another important point is the grouping of topics related to sea conditions (waves, currents, and hydrodynamics) into a single group with environmental monitoring and impacts. This shows that researchers are beginning to realize the following: to understand environmental damage, we must first understand the condition of the ocean. For example, how currents carry pollution or how waves affect coral. However, these topics are still somewhat on the periphery of the cluster, and their connection to the main conservation cluster is still weak. This suggests that marine science is still often viewed as a separate basic science, not yet fully utilized for designing practical conservation solutions in the field. Finally, the word "corals" here is different from "coral reefs" in the purple cluster. While "coral reefs" refers to the ecosystem broadly, "corals" in this red cluster is more about technical research on the biology of the coral itself, such as how the coral physically responds to temperature or water currents.

One of the most important and concerning findings of this analysis is the fate of the topic "mooring" (anchoring system). Although technically grouped in the blue cluster with management and tourism topics, the position of "mooring" on the map appears very isolated on the periphery. The connection to other topics is very thin and minimal. This shows that the academic world has not yet seriously integrated technical mooring solutions into discussions about sustainable tourism. Mooring is recognized as a part of management; however in practice, this topic is overlooked and is not linked to conservation or environmental issues.

This alienation has serious consequences. We know that mooring is essential to prevent damage to coral reefs from ship anchors. However, this topic rarely comes up in major discussions about conservation or environmental impact. In fact, mooring should be the main technical solution in maritime tourism.

Most likely, research on mooring has been conducted primarily in the marine engineering field (such as for the oil industry or large ports), rather than for coral conservation. This indicates a significant gap: engineering technicians are busy with their own mooring technology, while conservationists are busy protecting coral in other ways. These two worlds operate independently without any significant exchange of ideas or cooperation.

### *C. Comprehensive Interpretation of the Research Gaps*

The combination of density visualization and co-occurrence network analysis reveals fundamental characteristics of the current state of global research. First, the literature on marine conservation, environmental threats, and coral reef management (green, orange, and purple clusters) appears to be very mature and strongly integrated. Researchers have reached a consensus that marine protected areas and active environmental management are the most effective mechanisms for protecting these sensitive ecosystems.

Second, there are indications that the topic of tourism management (blue cluster) is beginning to conceptually connect with environmental issues, but this integration is still imperfect. The relationship tends to remain theoretical, while concrete technical infrastructure solutions—such as the implementation of mooring systems—are still lagging behind and are not yet considered an integral component of field practice.

Additionally, the analysis indicates that marine physical science (red cluster) is still treated as a basic discipline. Despite the importance of understanding physical parameters such as currents and waves, this knowledge has not been optimally used to design adaptive conservation solutions. The most significant and surprising finding was the absence of mooring systems from the main discussion. This topic is seldom discussed alongside coral reef conservation or sustainable tourism, indicating a fundamental separation between engineering and conservation biology. Both developed in their respective silos without any meaningful knowledge exchange.

### *D. Identification and Analysis of Specific Research Gaps*

Based on this analysis, two main interconnected gaps that need to be bridged were identified. The first gap is the lack of knowledge integration across disciplines. The highly advanced marine engineering expertise in the offshore industry has not yet met the urgent needs in the field of biological conservation. As a result, advanced mooring technology has not been effectively adapted for the context of coral reef protection. The second gap relates to spatial scale and implementation. The existing anchoring technology is generally designed for extreme deep sea environments with heavy-duty industrial specifications, making it unsuitable for application in shallow water areas where coral reef ecosystems are located.

This challenge is complicated by the unique characteristics of local waters, particularly in Indonesia, which has complex oceanographic dynamics such as double monsoon patterns and varying currents. Unfortunately, little research has systematically linked the understanding of these specific physical conditions to the design of conservation infrastructure. Historically, the application of technology has tended to adopt generic solutions without adequate adaptation to the local oceanographic context, potentially reducing the effectiveness of the tools and the sustainability of conservation programs. This confirms the need for a new approach that bridges physical environmental understanding with precise engineering design to support conservation success.

### E. Strategic Opportunities and Future Research Directions

The gaps identified above open strategic opportunities for future research to bridge the currently separate knowledge domains of management, conservation, coral reef ecosystems, fisheries, physical oceanography, and engineering. An integrative research framework is proposed to achieve this, starting with a detailed characterization of oceanographic conditions. Wave and current measurements must to be taken at priority tourist locations within a sufficient timeframe to obtain accurate data. This data must then be used as the basis for developing a mooring buoy design that is adaptive and specific to local water conditions, which is validated through numerical simulations before production.

Further research should also integrate technical aspects with ecological and socio-economic impact assessments. It is important to empirically prove that mooring installations are capable of reducing coral damage compared to traditional anchoring methods, while also ensuring that the solution is economically viable for tourism operators. Finally, the successful implementation of this technology is highly dependent on a community-based framework. The research should include the development of practical guidelines and management models that involve local communities in installation and maintenance to ensure the long term sustainability of conservation infrastructure.

## IV. CONCLUSION

This study identified and analyzed significant research gaps in the integration of mooring system technology and sustainable coral reef conservation in Indonesia. A comprehensive bibliometric analysis of data from 2015 to 2024 from the Lens.org database reveals six major thematic clusters. The research results indicate that keywords related to mooring remain in extreme positions with minimal co-occurrence with conservation objectives, despite strong connectivity among conservation, tourism, and management clusters. The extreme isolation of the topic of mooring from the main discussion of conservation and sustainable tourism literature demonstrates the existence of three interconnected gaps: a knowledge integration gap between offshore engineering and conservation literature; an implementation gap from deep water to tropical shallow water; and a specification gap related to Indonesia's unique oceanographic conditions, including monsoon patterns, tropical cyclone risks, and complex bathymetric variations. The real incident in Labuan Bajo in October 2025 highlights the urgency and relevance of this research, proving that this gap is not only a theoretical issue but also a practical challenge with a direct impact on coral reef ecosystems and sustainable tourism development. This study demonstrates that mooring buoy technology, which is well established in offshore engineering, can and should be integrated with environmental conservation through a multidisciplinary research approach that combines oceanography, structural engineering, and conservation principles. This study proves that both disciplines have developed independently without significant knowledge exchange. Therefore, developing a mooring system adaptable to Indonesia’s tropical shallow water conditions represents a strategic opportunity to bridge engineering knowledge with practical conservation solutions. Recommendations for future research include the following: developing mooring designs specific to Indonesian waters,

considering local oceanographic characteristics; numerical simulation of mooring systems under monsoon wave and current conditions; integrating mooring systems with real-time environmental monitoring technology; and developing a community-based sustainable framework involving local stakeholders, tourist boat operators, and conservation organizations. This research strategically addresses significant environmental challenges while promoting the economic sustainability of national tourism through a comprehensive strategy that integrates technical initiatives, environmental management, and regulatory policies to achieve comprehensive solutions that protect coral reef ecosystems while facilitating sustainable tourism development in Indonesia.

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