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SYSTEMATIC LITERATURE REVIEW AND FUTURE STUDY DIRECTIONS TO COASTAL RESILIENCE

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ABSTRACT

Coastal resilience is an important area of research because climate change, urbanization, and heavy coastal development are posing increasing threats. About 40% of the global population lives in coastal areas, which face major risks like rising sea levels, stronger storm surges, and damage to ecosystems. Urban growth, unsustainable economic practices, and the loss of natural protective features, such as mangroves and wetlands, make these problems worse. Indonesia, with its long coastline and large coastal population, illustrates the urgent need to improve coastal resilience, facing dangers like land sinking and loss of mangroves. This study uses a systematic literature review (SLR) and bibliometric analysis using VOSviewer, to look at global research trends in coastal resilience. Analyzing 260 academic journals shows that the United States leads in this field, due to its coastlines and academic resources, while countries like Indonesia and the UK also contribute significantly. The findings reveal that coastal resilience involves ecological, social, and economic aspects. Common keywords point out a focus on adaptive management, climate change effects, and ecosystem services, showing the complexity of improving resilience in vulnerable areas. Future research should focus on teamwork among different fields, connecting theories with practical solutions, and including resilience ideas in governance and policy-making. Policymakers should use local knowledge and prioritize sustainable practices to tackle current and future challenges. By encouraging collaboration and sharing findings in leading journals, the research community can improve understanding and implementation of effective coastal resilience strategies around the world.

Keywords : *Systematic Literature Review, Coastal Resilience, Adaptive Management, Climate Change*

ABSTRAK

Ketahanan pesisir telah muncul sebagai fokus penelitian yang penting karena meningkatnya ancaman dari perubahan iklim, urbanisasi, dan pembangunan pesisir yang intensif. Sistem pesisir, yang menopang hampir 40% populasi global, menghadapi risiko yang signifikan seperti naiknya permukaan air laut, meningkatnya gelombang badai, dan degradasi ekosistem. Tantangan-tantangan ini diperburuk oleh urbanisasi yang cepat, praktik ekonomi yang tidak berkelanjutan, dan hilangnya fitur perlindungan alami seperti hutan bakau dan lahan basah. Indonesia, dengan garis pantainya yang luas dan populasi pesisir yang padat, menjadi contoh urgensi untuk mengatasi ketahanan pesisir, menghadapi ancaman mulai dari penurunan tanah hingga penggundulan hutan bakau. Studi ini menggunakan metodologi tinjauan pustaka sistematis (SLR), yang mengintegrasikan analisis bibliometrik menggunakan alat-alat seperti VOSviewer untuk mengeksplorasi tren penelitian global dalam ketahanan pesisir. Analisis terhadap 260 jurnal akademis menyoroti kepemimpinan Amerika Serikat di bidang ini, yang didorong oleh garis pantai yang luas dan sumber daya akademis, di samping kontribusi signifikan dari negara-negara seperti Indonesia dan Inggris. Temuan-temuan utama menggarisbawahi sifat multidimensi ketahanan pesisir, yang meliputi dimensi ekologi, sosial, dan ekonomi. Kelompok kata kunci frekuensi tinggi mengungkapkan fokus pada manajemen adaptif, dampak perubahan iklim, dan layanan ekosistem, yang menekankan kompleksitas peningkatan ketahanan di wilayah-wilayah yang rentan. Penelitian di masa mendatang harus memprioritaskan pendekatan interdisipliner yang menjembatani kerangka kerja teoritis dengan aplikasi praktis, mengintegrasikan konsep ketahanan ke dalam tata kelola dan kerangka kerja kebijakan. Para pembuat kebijakan harus mengadopsi strategi inklusif yang memanfaatkan wawasan lokal dan memprioritaskan pembangunan berkelanjutan untuk mengatasi tantangan saat ini dan masa depan. Dengan mendorong kolaborasi dan menyebarluaskan temuan melalui jurnal-jurnal terkemuka, komunitas penelitian dapat memajukan pemahaman dan implementasi strategi ketahanan pesisir yang efektif secara global.

Kata Kunci : *Systematic Literature Review, Ketahanan Pesisir, Manajemen Adaptif, Perubahan Iklim*

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1. Preliminary

Coastal resilience has become an increasingly critical focus of environmental research and policy due to mounting threats from climate change, urbanization, and intensive coastal development. Coastal regions, which house approximately 40% of the global population, face significant challenges stemming from rising sea levels, intensified storm surges, and accelerated coastal erosion. These phenomena, exacerbated by climate change, pose risks to infrastructure, ecosystems, and livelihoods, especially in densely populated and economically significant coastal areas (Oppenheimer et al., 2019).

The effects of urbanization further compound these challenges. Rapid population growth and urban expansion in coastal zones have altered natural landscapes, leading to habitat loss, pollution, and increased vulnerability to extreme weather events (Roy et al., 2023). Infrastructure in these regions, often designed without considering long-term environmental risks, is particularly susceptible to damage, threatening both human safety and economic stability.

Moreover, economic development has often prioritized short-term gains over sustainable practices, resulting in over-exploitation of natural resources and the degradation of coastal ecosystems. Mangroves, coral reefs, and wetlands, which act as natural buffers against storms and flooding, are increasingly under threat from deforestation, land reclamation, and pollution. This loss not only diminishes ecological resilience but also undermines the socio-economic well-being of coastal communities (K et al., 2024).

Indonesia, as an archipelagic nation with over 17,000 islands and a coastline stretching more than 108,000 kilometers, is particularly vulnerable to coastal resilience issues. The country's coastal regions support approximately 60% of its population and contribute significantly to its economy, including fisheries, tourism, and trade. However, these areas face severe risks from climate change and human activities. According to the Indonesian National Disaster Management Authority (BNPB), around 115,000 hectares of coastal land are at risk of submersion due to sea-level rise by 2050. Major urban centers like Jakarta, Semarang, and Surabaya are already experiencing increased flooding, with Jakarta sinking at an alarming rate of 10 centimeters annually in some areas due to excessive groundwater extraction (Riama et al., 2021).

Furthermore, Indonesia has experienced a significant loss of mangrove forests, which play a crucial role in mitigating coastal erosion and absorbing carbon dioxide. A 2020 report by the Ministry of Environment and Forestry revealed that Indonesia had lost more than 600,000 hectares of mangroves over the past three decades (Ministry of Environment and Forestry, 2021). This deforestation not only increases vulnerability to storm surges but also contributes to biodiversity loss and reduced livelihood opportunities for coastal communities.

Given these multifaceted challenges, building and understanding coastal resilience is imperative. Coastal resilience refers to the capacity of coastal systems—both natural and human—to anticipate, absorb, adapt to, and recover from disturbances while maintaining their essential functions. It necessitates interdisciplinary approaches that integrate environmental science, socio-economic considerations, and policy frameworks.

2. Overview Theory

2.1. Resilience

The term was popularized in ecological studies by Holling in 1973, who defined resilience as the capacity of a system to absorb disturbances and reorganize while undergoing change to retain essentially the same function, structure, and feedbacks (Pisano, 2012). This perspective highlights two key dimensions: engineering resilience, which focuses on a system's ability to return to equilibrium after a disturbance, and ecological resilience, which emphasizes a system's capacity to adapt and transform in response to external pressures.

In socio-ecological systems, resilience extends beyond ecological boundaries to include human and institutional responses to change. According to (Walker et al., 2004), resilience comprises three critical attributes: the ability to absorb disturbances, the capacity for self-organization, and the capability to learn and adapt. This broader view integrates adaptive governance, social learning, and stakeholder participation, emphasizing the interconnectedness of human and natural systems in facing disruptions.

2.2. Coastal Resilience

Coastal resilience specifically refers to the capacity of coastal systems—encompassing natural ecosystems, built infrastructure, and human communities—to withstand, adapt to, and recover from external disturbances while maintaining their core functions. This concept is particularly relevant in the context of climate change, as coastal regions are increasingly exposed to risks such as rising sea levels, storm surges, coastal erosion, and ecosystem degradation (Gunderson, 2000).

The theoretical foundations of coastal resilience draw from both resilience theory and integrated coastal zone management (ICZM). Coastal resilience emphasizes the interplay of ecological, social, and economic dimensions (Steven et al., 2020; Zhang et al., 2023). For instance, ecological resilience in coastal areas involves the health and functionality of natural buffers such as mangroves, coral reefs, and wetlands, which protect against flooding and erosion. Meanwhile, Socio-economic resilience reflects the ability of coastal communities to adapt their livelihoods, access resources, and implement policies to mitigate risks. Infrastructural resilience pertains to the design and maintenance of coastal infrastructure, such as seawalls, ports, and drainage systems, to withstand extreme weather events and long-term environmental changes.

Key models, such as the Coastal Resilience Framework developed by The Nature Conservancy,

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integrate these dimensions into actionable strategies. The framework promotes the use of nature-based solutions (e.g., mangrove restoration), participatory planning processes, and adaptive management to enhance the resilience of coastal zones (Lebbe et al., 2021).

In the Indonesian context, the concept of coastal resilience incorporates traditional knowledge, governance structures, and community-based approaches. Local adaptations, such as pagar laut (sea fences) and mangrove conservation initiatives, are examples of efforts to align scientific and traditional strategies. These practices underline the importance of a localized, inclusive approach to resilience planning (Brown et al., 2014).

By synthesizing these theoretical underpinnings, this systematic literature review aims to explore and map the state of knowledge on resilience and coastal resilience. The integration of diverse theoretical perspectives facilitates a deeper understanding of the dynamics of coastal systems and provides insights for developing robust, adaptive strategies to enhance resilience.

3. Method or Stages

The proposed systematic literature review (SLR) methodology integrates advanced bibliometric tools and databases to ensure a comprehensive and robust analysis. The research stages include database search and filtering, data collection, and mapping analysis (Moher et al., 2019; Mengist et al., 2020). These steps are designed to address the title's focus using **Scopus search** via **Publish or Perish** and bibliometric analysis with **VOSviewer**.

3.1. Planning Stage

3.1.1. Defining Research Objectives

This study aims to map the state of knowledge on coastal resilience by analyzing global research trends and identifying critical areas of scholarly activity. Specifically, it seeks to uncover research clusters, highlight the most frequently used keywords, and identify the journals most active in publishing studies on coastal resilience. These objectives provide a roadmap for understanding the academic landscape and pinpointing areas for future exploration.

3.1.2. Research Questions

To explore the dynamics of coastal resilience research, this study addresses three primary questions:

a. What are the most influential countries in coastal resilience research?
b. What keywords are most frequently associated with coastal resilience?
c. Which journals publish the majority of coastal resilience research?

3.1.3. Protocol Development

a. Develop a search string tailored for Scopus to ensure coverage of relevant studies:
b. Set inclusion criteria:
   - Publications from 2015 to 2024.
   - Peer-reviewed articles only.
   - English-language articles.
   - Keywords: Adaptive management, climate change adaptation, and community resilience.
   - Subject area: Environmental Science

c. Set exclusion criteria:
   Non-academic sources, book chapters, and non-peer-reviewed conference papers.

3.2. Data Collection Stage

Data Search Using Publish or Perish

a. Configure **Publish or Perish** to query the **Scopus** database.
b. Use the search string and apply filters (date, document type, language).
   TITLE-ABS-KEY (coastal AND resilience) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (SUBJAREA, "ENVI")) AND (LIMIT-TO (EXACTKEYWORD, "Adaptive Management") OR LIMIT-TO (EXACTKEYWORD, "Community Resiliences") OR LIMIT-TO (EXACTKEYWORD, "Climate Change Adaptation")) AND (LIMIT-TO (DOCTYPE, "ar"))
c. Export the dataset in RIS or CSV format for further analysis.

3.3 Data Analysis and Mapping

3.3.1 Bibliometric Analysis with VOSviewer

a. Import the cleaned dataset into VOSviewer.
b. Perform bibliometric analysis using the following approaches:
   - **Keyword Analysis**: Map frequently occurring keywords to identify dominant themes and trends.
   - **Country Analysis**: Visualize the contribution of different countries to coastal resilience research.
   - **Journal Analysis**: Identify journals with the highest publication volumes on the topic.

3.3.2. Network Visualization

VOSviewer is used to generate network maps based on co-occurrence and co-authorship relationships as follows:

a. *Keyword Map*: Visualize keyword clusters to reveal the thematic structure of the field.
b. *Country Map*: Highlight collaborations and research output by country.

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c. *Journal Map*: Identify leading journals contributing to the literature.

3.4. Synthesis and Interpretation

The synthesis and interpretation stage consolidates the findings from earlier analyses to generate meaningful insights into coastal resilience research. By integrating data from thematic, country-level, and journal-level evaluations, this stage seeks to identify critical gaps and emerging areas of study. Through a systematic exploration of the research landscape, this section aims to provide a foundation for advancing the understanding of coastal resilience in both theoretical and practical dimensions.

3.5. Reporting Stage

The reporting stage transforms the insights gained from the analysis into comprehensive and accessible outputs. By leveraging advanced visualization techniques and structured reporting frameworks, this stage ensures that the findings are effectively communicated to diverse stakeholders. Emphasizing clarity and precision, the reporting process aims to amplify the contributions of this systematic review to the broader discourse on coastal resilience.

By following these stages, the study will ensure a systematic and replicable approach to understanding the global research landscape of coastal resilience.

4. Results and Discussions

This research investigates journal articles published between 2015 and 2024 that focus on the topic of coastal resilience. Utilizing the Scopus database, the study identified a total of 260 journals that meet specific criteria related to coastal resilience, particularly within the context of coastal resource management. The analysis encompasses a wide range of topics, including strategies for mitigating the impacts of climate change, the sustainability of coastal ecosystems, and community resilience in the face of environmental challenges. This comprehensive approach aims to provide a deeper understanding of the current literature and research trends surrounding coastal resilience.

4.1 Descriptive Analysis Literature Based on State

Coastal resilience research has gained significant traction across the globe, reflecting increasing awareness of the challenges posed by climate change, natural disasters, and environmental degradation. A comprehensive mapping of 260 academic journals worldwide that focus on coastal resilience has been conducted. The findings, illustrated in Figure 1, indicate that the United States is at the forefront of this research endeavor, publishing the highest number of studies related to coastal resilience. This trend highlights not only the wealth of academic resources in the U.S. but also the country's commitment to addressing the complex issues affecting coastal communities and ecosystem.

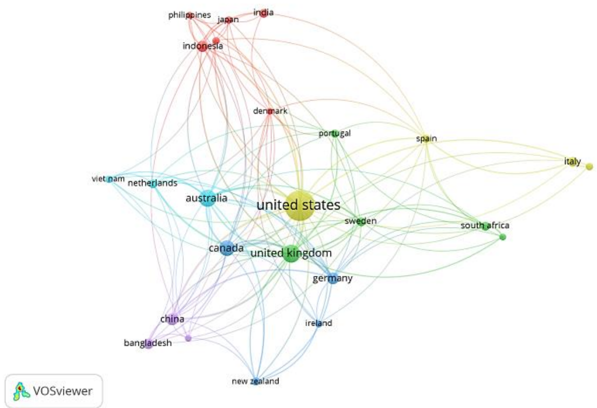

Figure 1. *Mapping of Coastal Resilience Research by Country*

A study from USA develops a spatio-temporal framework to assess the vulnerability of urban salt marshes to sea-level rise by integrating ecosystem services into ecological risk assessment. Tested at Belle Isle Marsh, the model evaluates changes in services like carbon storage, nitrogen storage, fish nurseries, and wildlife viewing through the century. Findings reveal trade-offs, with sea-level rise causing habitat fragmentation and loss, impairing carbon storage and wildlife viewing, but temporarily enhancing fish nursery and nitrogen storage. The framework provides insights for proactive planning and adaptation to future challenges (Alemu I et al., 2024).

Another study from US examines climate change adaptation planning in 16 Gulf of Alaska communities reliant on fisheries and marine industries. It finds that local plans, such as hazard management and comprehensive plans, emphasize habitat protection but often overlook climate change stressors. The analysis highlights gaps in addressing social resilience and integrating fisheries and marine industry needs into climate planning. It argues for embedding climate change adaptation within existing planning frameworks to enhance inclusivity and social resilience, providing pathways for more effective integration despite limited political support and funding (Szymkowiak et al., 2023).

However, research from other countries has also been widely used, such as research from UK. This study highlights the increasing prominence of resilience as a key concept in coastal management but notes its limited operationalization. The paper emphasizes the need for stronger government commitment, inter-agency cooperation, and adaptive governance to embed resilience into national policy and management practices effectively (Townend et al., 2021).

Based on the Figure 2, the USA emerged as the top nation in pioneering research on coastal resilience in 2020. The United States has firmly positioned itself as a leader in coastal resilience research, largely because of its extensive and diverse coastlines, which are highly vulnerable to natural disasters such as hurricanes, rising sea levels, and flooding. These environmental threats are

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heightened by the country's geographic location and climate conditions.

In response to these crises, numerous initiatives have emerged that focus on enhancing resilience in coastal communities. Policymakers, scientists, and local stakeholders are increasingly collaborating to address the complexities of climate change and its impacts on coastal ecosystems and human settlements. This collaboration encompasses a range of activities, from conducting in-depth risk assessments to implementing adaptive management practices and community planning efforts.

Moreover, over the last few years, there has been a marked increase in policy focus on climate adaptation and resilience planning. This shift reflects a growing understanding of the urgent need to protect vulnerable coastal areas, which are not only essential for their ecological value but also play a critical role in the economy, providing livelihoods through tourism, fishing, and trade (IPCC, 2023). Ultimately, coastal resilience research is a pivotal area of study, as it directly impacts the sustainability and well-being of millions of people who live and work in these vital regions of the United States (Kim et al., 2014).

In 2021 and the subsequent year, several countries, including Indonesia, have been recognized for increasing their research efforts focused on coastal resilience. A research examines climate change adaptation efforts in Jakarta's coastal communities, focusing on risks shaped by geographical and socioeconomic factors. The study identifies inadequate dredging as a major issue reducing the effectiveness of flood canal projects. Findings emphasize the importance of freshwater facilities, local business promotion, and leveraging social capital to enhance resilience. By integrating technical solutions with local knowledge and community engagement, the research provides a governance framework for coastal management, offering insights for policymakers and practitioners in Indonesia and beyond (Purnomo et al., 2024).

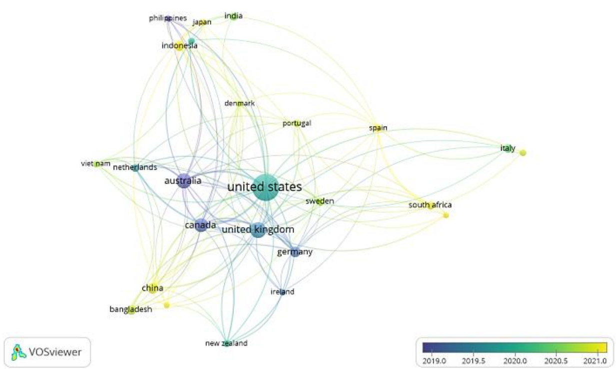

Figure 2. *Mapping of Coastal Resilience Research by State vs. Year*

4.2. Descriptive Analysis Literature Based on Keywords

Research on coastal resilience is inherently connected to a range of factors that both influence and support its development and implementation. This interconnectedness highlights the importance of understanding various environmental, social, and economic variables that contribute to the overall resilience of coastal areas. In order to visualize these relationships, Figure 3 presents a chart that maps the keywords associated with coastal resilience, illustrating how different terms and concepts are linked to this critical topic. This diagram serves as a valuable tool for identifying the multifaceted nature of coastal resilience and the different dimensions that need to be considered in research and practice.

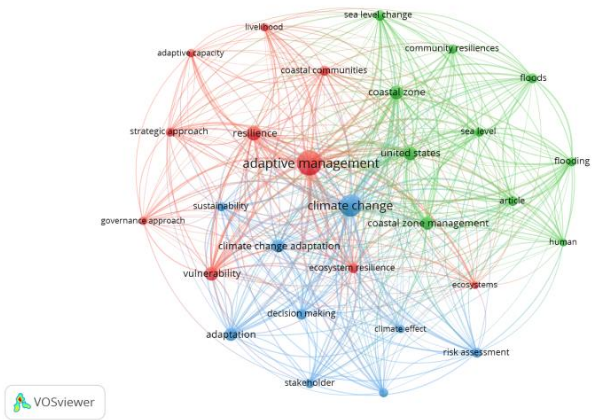

Figure 3. *Mapping of Coastal Resilience Research Based on All Keywords*

A total of 2526 keywords were analyzed using a minimum threshold for keyword occurrences of 20, resulting in the identification of 29 keywords. The visualization in Figure 3 illustrates high-frequency keyword clusters, represented by three color clusters: red (10 keywords), green (10 keywords), blue (9 keywords).

Figure 3 highlights the intricate relationship between coastal resilience and several critical factors, including climate change and adaptive management strategies. Coastal resilience refers to the ability of coastal ecosystems and communities to withstand and recover from environmental stressors, particularly those associated with climate change such as rising sea levels, increased storm intensity, and coastal erosion (Masselink & Lazarus, 2019). Adaptive management plays a key role in this process by involving a systematic approach to planning, implementing, and assessing management strategies that can be adjusted based on the changing conditions and new knowledge gained over time (Williams & Brown, 2014).

Moreover, coastal resilience is closely related to ecosystem resilience, which is the capacity of ecosystems to absorb disturbances while maintaining their essential functions and processes (Gunderson, 2000). The vulnerability of these coastal areas also influences resilience, as regions that are more susceptible to

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environmental changes require more robust management efforts (Mafi-Gholami et al., 2020).

Additionally, effective coastal zone management is essential to enhance resilience, involving the integration of various practices and policies designed to protect, restore, and sustainably manage coastal resources. These interconnected elements underscore the complexity of maintaining coastal resilience in the face of ongoing climate challenges.

4.3. Descriptive Analysis Literature Based on Journal

The research on coastal resilience has garnered significant attention and has been extensively published across a variety of academic journals, especially those dedicated to environmental science and coastal management. These publications contribute valuable insights into understanding and enhancing the resilience of coastal ecosystems and communities in the face of climate change and other environmental challenges. Table 1 presents the most active journal source for publications related to coastal resilience.

Table 1. *Most active source titles for publications related to coastal resilience*

Source	Doc.	Cit.	Total Link Strength
ocean and coastal management	24	448	655
sustainability (switzerland)	21	244	385
marine policy	17	342	450
science of the total environment	12	272	318
Coastal Management	10	280	265
journal of environmental management	8	213	272
ecology and society	7	245	295
Climate Change	7	311	197
journal of coastal research	7	113	149
land use policy	6	127	188
environmental management	6	74	214
Natural Hazards Review	6	167	151
water (switzerland)	6	182	136
Mitigation and adaptation strategies for global change	5	10	107

Source: VosViewer Analyis, 2024

Figure 4 presents a comprehensive mapping study that visually represents the scope of research on coastal resilience. This figure highlights the journals that have published the most articles on the subject, showcasing the most influential contributors to the field. By analyzing the distribution of these publications, we can better comprehend the current state of research and identify trends, gaps, and emerging areas for further investigation in coastal resilience.

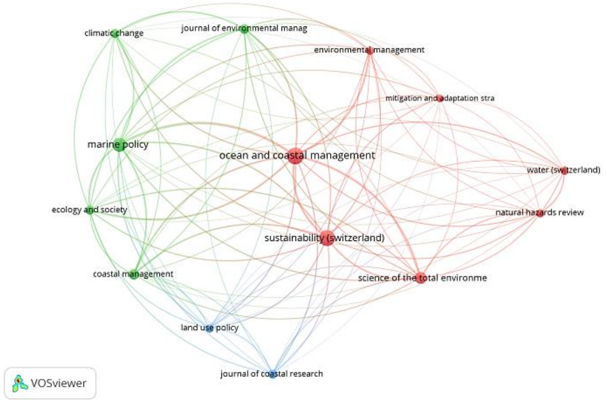

Figure 4. *Mapping of Coastal Resilience Based on Journal*

Based on the data presented in Figure 5, it is evident that several academic journals are dedicated to research on coastal resilience, with varying quantities of published articles. The Journal of Ocean and Coastal Management stands out as the leading publication, featuring a total of 24 research papers focused on this vital topic. Following closely is the journal Sustainability (Switzerland), which has contributed 21 papers, while Marine Policy occupies the third position with 17 publications.

A particularly insightful study published in the Journal of Ocean and Coastal Management revisits the concept of resilience specifically in relation to major natural hazards (Jessin et al., 2024). The authors argue for the necessity of conducting precise assessments that utilize contextualized indicators rather than relying solely on generalized metrics. Traditional evaluations of resilience often depend on aggregated data, which can obscure the unique challenges faced by specific coastal areas. This research introduces a novel approach by employing data collected from Unmanned Aerial Vehicles (UAVs), allowing for site-specific, rapid updates that are especially critical in the aftermath of extreme weather events.

Focusing on Bora Bora as a case study, the researchers identified key indicators for what they term Territorial Resilience Potential (TRP) concerning various coastal hazards. These indicators serve as essential tools for assessing how well a coastal region can withstand and recover from adverse conditions. The findings from this study are designed to support decision-making processes through the implementation of spatial decision support systems. Ultimately, the goal is to guide the development of long-term adaptation and protection strategies that enhance the resilience of coastal territories, ensuring they can effectively respond to and recover from the impacts of climate change and other environmental stresses.

5. Conclusions and Recommendations

This study analyzes research trends in coastal resilience and highlights its growing importance in

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dealing with climate change, environmental damage, and natural disasters. Using the Scopus database, the study identified 260 academic journals, showing a worldwide effort to find ways to strengthen coastal ecosystems and communities. The United States leads in coastal resilience research due to its long and vulnerable coastlines and strong academic resources. Other countries, like Indonesia and the UK, also make important contributions, focusing on local issues and governance.

Research in coastal resilience connects to important topics like climate change, adaptive management, and ecosystem health. Common keywords show the complex nature of maintaining resilience, including themes like coastal zone management and vulnerability assessments. A variety of journals support this research, with "Ocean and Coastal Management" being the most published, followed by "Sustainability (Switzerland)" and "Marine Policy." These journals share new methods and policy solutions to improve coastal resilience. The findings point to the need for approaches that combine technical, social, and ecological perspectives to effectively address the various challenges of coastal resilience.

Future research on coastal resilience should focus on key variables directly linked to this issue and aim to bridge the gap between theoretical frameworks and practical applications. It is crucial to integrate resilience concepts into governance and policy frameworks to ensure actionable strategies.

Research must emphasize adaptive management strategies that recognize the value of ecosystem services and actively engage local communities, leveraging their insights for effective management practices. Policymakers should prioritize these inclusive approaches to develop proactive policies that address current and future coastal challenges.

Additionally, researchers should submit their findings to respected journals like the Ocean and Coastal Management Journal, which specializes in coastal resilience studies, to promote collaboration and enhance understanding of coastal issues.

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