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Original Research Paper

From Conservation to Regeneration: A Paradigm Shift in Seagrass-Ecotourism Management and Innovation Opportunities for Indonesia

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Abstract

Seagrass meadows are among the most productive coastal ecosystems, yet they are estimated to experience annual losses of approximately 7% due to ongoing conflicts between conservation objectives and local livelihood needs. This study maps the evolution of seagrass–ecotourism research from 2016 to 2025 and proposes a regenerative tourism framework tailored to the Indonesian context. A hybrid bibliometric analysis of 235 scientific publications was conducted, complemented by a Systematic Literature Review (SLR) of 27 key articles selected for relevance and methodological rigor. Knowledge structures and thematic clusters were visualized to identify dominant research trends and gaps. The results reveal a paradigm shift from ecology-centered studies toward integrated socio-economic and governance-oriented approaches. Indonesia contributes 41% of global research output, highlighting its role as a major seagrass hotspot and living laboratory for conservation-based tourism. Empirical evidence shows that integrating Regional Public Service Agency (BLUD) governance with Blue Carbon financing mechanisms, as observed in Raja Ampat, has strengthened financial support for seagrass conservation and restoration. Overall, the findings indicate a transition from passive conservation to regenerative management, where ecotourism serves as a strategic financing engine for ecosystem recovery. Integrating Indigenous and Local Knowledge (ILK) with carbon trading schemes is crucial to ensure long-term sustainability and resilience of seagrass ecosystems in the Anthropocene.

Keywords: Bibliometric analysis; Blue carbon; Ecotourism; Regenerative tourism; Seagrass.

INTRODUCTION

Seagrass beds are one of the most productive ecosystems in the biosphere, yet their existence is often marginalized in global conservation discourse, which tends to favor visually striking ecosystems such as coral reefs. Functionally, however, seagrass beds play a vital role as coastal life support systems. Recent studies confirm that seagrass beds are not merely habitats, but crucial natural infrastructure for climate change mitigation. The carbon storage capacity (*Blue Carbon*) of this ecosystem can bury organic carbon in sediments up to 35 times faster than tropical rainforests, making it an invaluable asset in the global carbon market (Macreadie *et al*., 2021; Orth *et al*., 2006). In addition to their carbon sequestration function, seagrass beds provide ecosystem services as nursery grounds for 20% of the world's commercial fish stocks, directly supporting the food security of millions of coastal communities (Unsworth *et al*., 2019; Waycott *et al*., 2009).

However, irony prevails in the current Anthropocene era. Anthropogenic pressures ranging from eutrophication, coastal reclamation, to climate change are increasing exponentially. Historically, Waycott *et al*. (2009) estimated a loss rate of 7% per year, although recent studies show more varied trends (Dunic *et al*., 2021). This degradation crisis not only means the loss of biodiversity but also the release of ancient carbon stocks stored in sediments back into the atmosphere, which exacerbates global warming. Therefore, a business-as-usual management approach is no longer adequate to stem the rate of damage.For decades, coastal governance has been stuck in the classic dichotomy between "*strict conservation*" and "*economic development*." The old conservation paradigm was often defensive (*fortress conservation*), seeking to fence off nature and separate it from human interaction. This approach often fails because it ignores the socio-economic realities of coastal communities that depend on marine resources for their livelihoods (Sondita *et al*., 2020). When conservation regulations are enforced without providing viable economic alternatives, resistance from local communities is inevitable.

This phenomenon has given rise to many "paper parks" in Indonesian conservation areas that exist only administratively on maps, but are ineffective in terms of law enforcement and management in the field due to a lack of operational funding and social support (Risandi *et al*., 2023; Bennett & Dearden, 2014). In response to this failure, recent literature has begun to highlight a fundamental shift towards the paradigm of "*Regenerative Tourism*." This concept goes beyond sustainable tourism, which has been the gold standard. While sustainable tourism focuses only on impact neutrality or "minimizing damage" (*not harm*), regenerative tourism demands a net positive impact or restoration (*do good*) (Bellato *et al*., 2023; Duxbury *et al*., 2021). In the context of

seagrass beds, the regenerative model positions tourists not merely as admirers of natural beauty, but as "*prosumers*" (producers and consumers) who actively participate in ecosystem restoration (Hussain, 2024). Through this approach, income from tourism is converted into a sustainable funding mechanism for seagrass restoration and economic incentives for local communities. Tourists can engage in citizen science activities, such as seagrass health monitoring or seedling planting, which transforms tourism from an extractive threat into an engine of ecological recovery (Blangy & Mehta, 2006; Ateljevic, 2020).

Indonesia, as an archipelagic country with an estimated seagrass area of 3 million hectares and a global center of seagrass biodiversity, plays a key role in this global transition (Kawaroe *et al*., 2016). The current national policy momentum is very supportive, especially with the issuance of Presidential Regulation No. 98/2021 on Carbon Economic Value. This regulation provides a solid legal basis for integrating Blue Carbon potential into tourism economic schemes, enabling the monetization of carbon sequestration services by seagrass beds to support conservation (Government of the Republic of Indonesia, 2021; Alongi *et al*., 2016). Based on these urgencies and opportunities, this study was designed to fill the knowledge gap in the implementation of regenerative models in seagrass ecosystems. This study aims to: (1) map global research trends on ecotourism-based seagrass meadow management through bibliometric analysis to identify research novelty; and (2) formulate an adaptive regenerative tourism framework based on a synthesis of empirical evidence from three strategic locations: Sekotong, Raja Ampat, and Berau. This framework is expected to serve as a practical guide for transforming the challenges of seagrass degradation into opportunities for ecosystem restoration and community welfare.

RESEARCH METHODS

Research design

This study applies a hybrid methodological approach that integrates quantitative bibliometric analysis with qualitative Systematic Literature Review (SLR). This integration is designed to overcome the limitations of each method when conducted separately. While bibliometric analysis is effective in mapping the "*intellectual landscape*" and macro structure of global knowledge, such as publication trends, author collaboration networks, and keyword clusters (Donthu *et al*., 2021). This method tends to treat documents as "*black boxes*" and is unable to reveal the depth of substantive findings within them. Therefore, the use of SLR is a crucial instrument in this study to complement the numerical data.

The application of SLR in this study is based on three main methodological imperatives. First, SLR enables an in-depth synthesis of complex theoretical constructs, such as the transition from sustainable to regenerative tourism, which cannot be captured solely through keyword frequency. Snyder (2019) asserts that SLR provides a transparent and reproducible framework for identifying, evaluating, and interpreting all available research, thereby minimizing the selection bias that often occurs in traditional narrative reviews. Second, in the context of coastal ecosystem management, empirical evidence is often scattered across heterogeneous qualitative case studies. SLR serves to aggregate these fragmented findings into a cohesive framework (Tranfield *et al*., 2003). Third, this combination allows for cross-validation, where bibliometrics identify who and what is trending, while SLR answers how and why these phenomena occur (Zupic & Čater, 2015). The entire process of selecting and screening articles in this study followed the strict Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (Page *et al*., 2021).

Research procedure

Global literature data collection was conducted through the Dimensions.ai database, spanning ten years (2016-2025). This period was purposively selected to capture the surge in research trends following the ratification of the Sustainable Development Goals (SDGs) and the Paris Agreement. Dimensions.ai was chosen as the sole data source due to its advantage in bridging the coverage gap between strictly curated databases such as Scopus (an Elsevier product) and Web of Science (WoS), and open databases such as Google Scholar.

Although Scopus and WoS are recognized as the gold standard in bibliometrics, several comparative studies show that both have a strong geographical bias towards "Global North" journals, often overlooking crucial literature from developing countries (Visser *et al*., 2021; Mongeon & Paul-Hus, 2016). On the other hand, Google Scholar offers the widest coverage but has unstructured metadata that is difficult to validate for bibliometric analysis (Martín-Martín *et al*., 2018). Dimensions.ai offers an optimal middle ground solution; this platform indexes reputable journals in Scopus, while also covering regional publications relevant to seagrass topics in island countries, with a neat data structure (Herzog *et al*., 2020). The search was conducted using query strings with Boolean logic: (*seagrass OR "seagrass meadow"*) AND *(ecotourism OR tourism*) AND (*management OR conservation*). Through this filtering protocol, 235 documents were successfully retrieved for further analysis.

Research data analysis

Bibliometric analysis was performed using VOSviewer software version 1.6.20 to map keyword co-occurrence and identify research theme clusters (Van Eck & Waltman, 2010). The analysis parameters used binary counting with a minimum keyword occurrence threshold of 3 times. For qualitative analysis, gradual filtering (title, abstract, and full text filters) was performed on 235 initial documents, resulting in 27 core articles that were relevant in substance. This data was then triangulated with policy reports (*grey literature*) from credible institutions such as YKAN, CarbonEthics, and government documents (YKAN, 2024; CarbonEthics, 2024).

RESULTS AND DISCUSSION

Publication Dynamics and Temporal Trends

Temporal trend analysis of publications is a fundamental indicator in bibliometric studies to measure the evolution of scientific community interest in a specific topic over time. In the context of coastal resource management, publication trajectories often reflect academics' responses to

global agendas, such as the Sustainable Development Goals (SDGs) and the climate crisis (Donthu et al., 2021). In particular, the intersection between seagrass ecosystems and tourism has transformed from a niche topic to a central issue in the Blue Economy discourse. This surge in attention has been driven by a growing global awareness that tourism is not only an economic sector but also a potential tool for financing marine conservation (Spalding et al., 2017; Bennett & Dearden, 2014). Therefore, mapping the annual distribution of publications is a crucial step in understanding the maturity of this research domain.

Based on data filtering from the Dimensions.ai database (Figure 1), analysis of 235 indexed documents reveals significant growth in the volume of ecotourism-based seagrass management research. Cumulatively, there has been a +950% surge in publications over the past decade, moving from just 4 documents in 2016 to an estimated 42 documents in 2025.

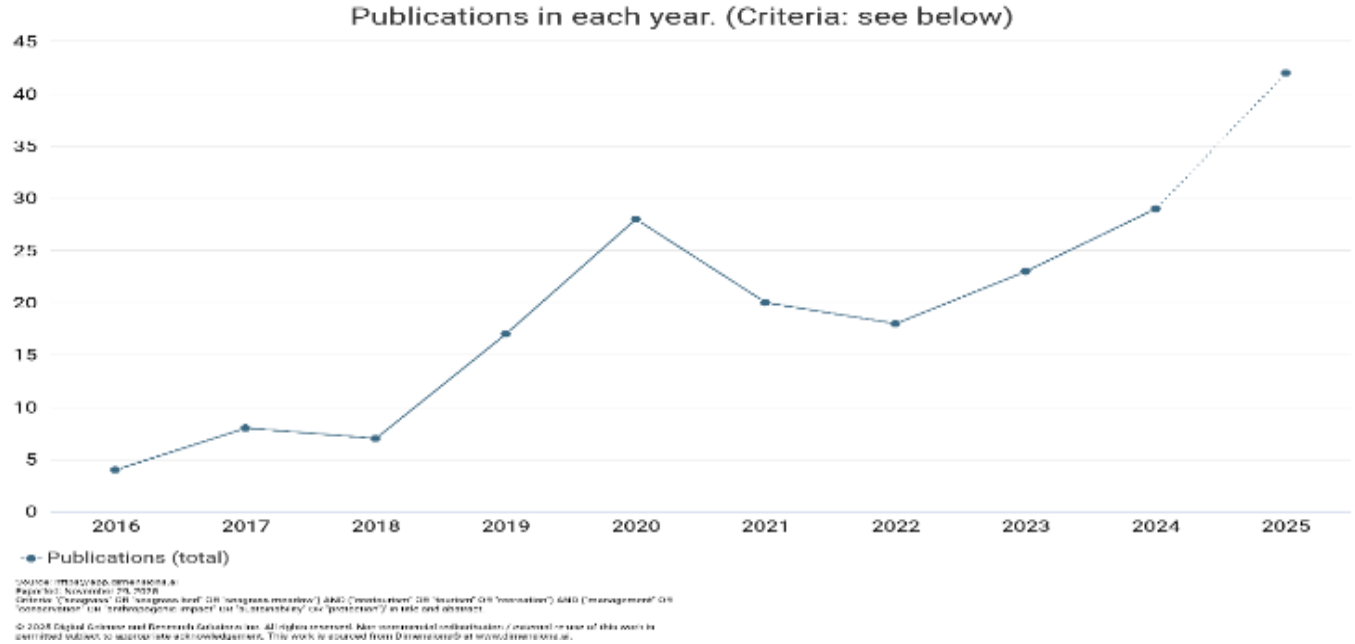

Figure 1. Publication trends in seagrass-ecotourism research (2016-2025)

The data in Figure 1 shows a non-linear distribution pattern, which can be categorized into three distinct evolutionary phases: Foundation Building Phase (2016-2019): This period was marked by slow but steady growth, starting with 4 publications (2016) and gradually increasing to 17 publications (2019). Pandemic Fluctuation Phase (2020-2022): There was an initial surge to 28 publications in 2020, followed by a decline (plateau) to 20 in 2021 and the lowest point of this phase at 18 in 2022. Exponential Growth Phase (2023-2025): Research rebounded aggressively, rising to 23 (2023), 29 (2024), and is projected to peak at 42 in 2025.

The dynamics shown in Figure 1 are not a statistical coincidence, but rather a reflection of macro-external events that affect the global research ecosystem: Phase 1 (Initiation): The low number of publications at the beginning of the period (2016-2019) indicates that the integration of the issues of "seagrass" and "tourism" was still in the early conceptual stages. Research focus at that time was dominated by basic seagrass biology without deep integration with the socio-economic aspects of tourism (Unsworth et al., 2019). Phase 2 (Impact of COVID-19): The anomaly of decline in 2021-2022 can be explained by the impact of the COVID-19 pandemic. Given that tourism and marine ecology research are highly dependent on fieldwork, global travel restrictions significantly hampered the collection of primary data (Gössling et al., 2021). The decline in publication output in 2021-2022 is a lag effect of the suspension of field research in 2020. The dramatic resurgence from 2023 to 2025 is driven by the momentum of the UN Decade of Ocean Science for Sustainable Development (2021-2030) and the recovery of the global tourism sector with a new, more environmentally friendly paradigm (nature-based tourism). In addition, global recognition of seagrass beds as major carbon sinks (Blue Carbon) in climate mitigation has attracted new research funding, which integrates carbon credit schemes with tourism (Macreadie et al., 2021; Bellato et al., 2023). This trend confirms that seagrass research has now shifted from mere biological conservation to a strategic issue in the global environmental political economy.

Global Knowledge Cluster Map

Keyword co-occurrence analysis is a powerful bibliometric method for visualizing the cognitive structure or "intellectual landscape" of a field of research. As explained by Zupic & Čater (2015), the frequency of cooccurrence of two keywords in various documents reflects the thematic proximity and conceptual relationships between the issues being studied. In the context of natural resource management, this mapping not only identifies dominant topics but also reveals the paradigmatic evolution of how the scientific community's focus has shifted over time in response to global challenges (Donthu et al., 2021). Through network visualization, we can trace the transition from purely ecological research to a more integrative and socio-ecological approach.

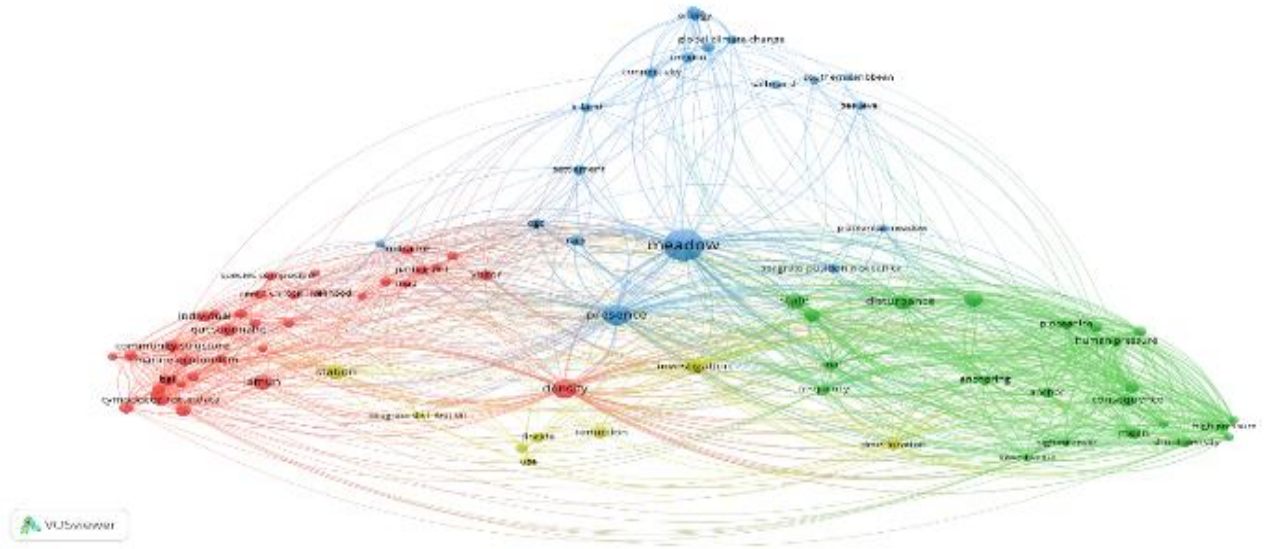

Figure 2. Visualization thematic map showing disciplinary clustering

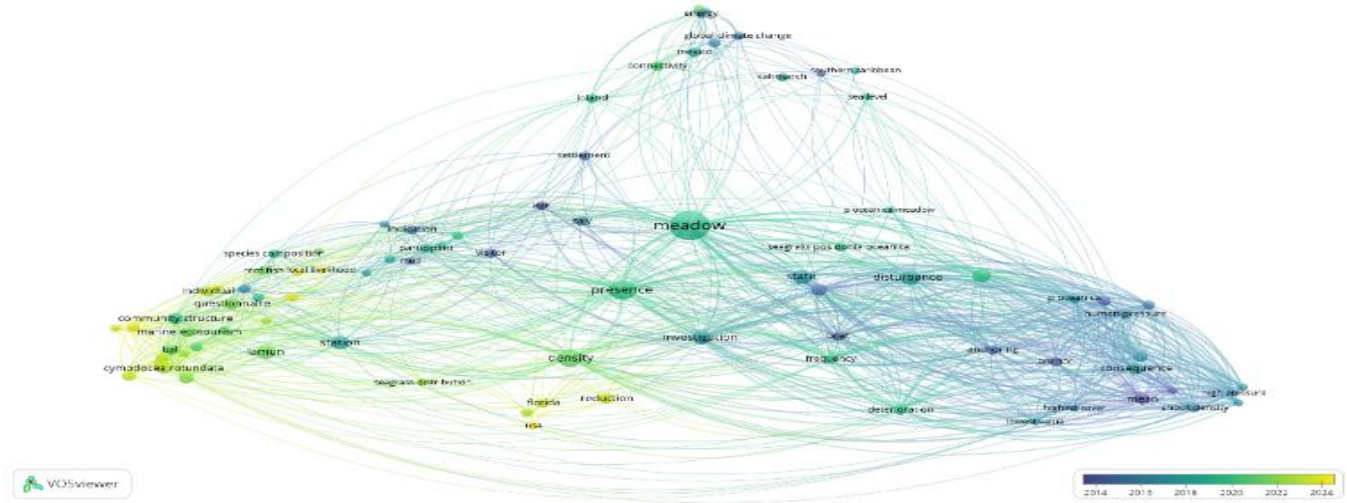

Figure 3. Overlay keyword co-occurrence network map showing temporal evolution of seagrass-ecotourism research**.**

The VOSviewer network visualization in Figure 2 and the temporal overlay map in Figure 3 reveal a polarized yet interconnected knowledge structure. Based on modularity analysis, three main clusters were identified, representing the historical and thematic journey of global seagrass ecotourism research. A detailed interpretation of these three clusters is summarized in Table 1 and described as follows:

Table 1. Interpretasi Klaster Riset: Evolusi Tiga Domain Pengetahuan

Dimensions	Cluster 1: Ecological Foundation (Mature)	Cluster 2: Anthropogenic Impact (Growing)	Cluster 3: Socio-Economic Integration (Emerging)
Key Words	meadow, density; species; distribution; biomass	Disturbance; human pressure; boat, anchoring; impact	Community; stakeholder; willingness-to-pay; management
Research Focus	Species inventory, distribution mapping, and community structure.	Impact of boat anchors, tourism carrying capacity, and physical damage.	Community perceptions, economic valuation, local wisdom, and collaborative governance.
Dominant Period	2014 – 2020	2016 – 2024	2019 – 2025
Key Questions	“What species are there?”	“What is the impact of tourism on seagrass?”	“How does tourism finance conservation?”
Study Representation	Sjafrie et al. (2018); Fahruddin et al. (2023)	Kaber et al. (2023); Unsworth et al. (2018)	Rifai et al. (2024); Abas et al. (2021)

Ecological Foundation Cluster (Mature/Established) This cluster (seen as dominant in the blue/purple nodes in the center of the map) represents the early phase of research focused on inventorying natural assets. Dominant keywords such as "meadow," "presence," "species," and 'density' indicate that the main priority of scientists in the past decade was to answer the basic questions: "What is there and how widespread is its distribution?" Research in this cluster laid crucial biophysical foundations, documenting seagrass community structure as a prerequisite for any conservation efforts (Sjafrie et al., 2018; Fahruddin et al., 2023). Without the fundamental understanding of seagrass biology built during this phase, ecosystem service valuation would have been impossible.

Anthropogenic Impact Cluster (Transition) The second cluster (green nodes on the right side) marks a shift in attention toward threats and degradation. Keywords such as "disturbance," "anchoring," "boat," and "human pressure" are central. This reflects researchers' reactive response to physical damage to seagrass beds caused by uncontrolled human activities, particularly from the marine tourism sector (boat anchoring and boat traffic). Studies in this cluster, such as those conducted by Unsworth et al. (2018) and Kaber et al. (2023), focus on calculating ecological losses and environmental carrying capacity, shifting the narrative from simply "seagrass existence" to "seagrass vulnerability."

Socio-Economic Integration Cluster (Emerging/Latest) The third cluster (red/yellow nodes on the left side, see Figure 3 for novelty indicators) is the most dynamic and rapidly developing domain after 2019. Keywords such as "marine ecotourism," "community structure," "questionnaire," "local livelihood," and "willingness-to-pay" dominate. The appearance of bright yellow in Figure 3 in this area confirms that this is state-of-the-art research at present. The focus of research has fundamentally transformed: from viewing humans solely as a threat (cluster 2) to viewing humans as partners in solutions. Recent research explores the human dimension, collaborative governance, and how tourism can finance conservation (Rifai et al., 2024; Abas et al., 2021). This confirms that the global paradigm is moving towards a "Regenerative Tourism" model, where the ecological and economic aspects of local communities are integrated into a single management framework.

Research Gap Analysis

The fundamental purpose of systematic literature reviews and bibliometric analysis is not merely to summarize what is already known, but to uncover what is "unknown" or the known unknowns (Snyder, 2019). Identifying research gaps is a critical step in defining the novelty of a doctoral/master's study. In the context of seagrass management and ecotourism, keyword density mapping allows researchers to distinguish between saturated topics and underexplored areas. Through the density visualization approach, we can see the contrast between the "Red Ocean" of dense research competition and the "Blue Ocean" of new research opportunities with potential for development (Donthu et al., 2021; Aria & Cuccurullo, 2017).

Analysis of Figure 4 reveals that the majority of academic attention over the past decade has been focused on bio-physical inventory aspects. Keywords such as meadow, presence, density, and distribution have the highest color intensity. This confirms that the scientific community has been very established in answering the questions "where are seagrasses located and how many are there?" However, there is a clear void or gap in the peripheral areas of the map, which represents the integration of advanced technology and complex climate financing mechanisms.

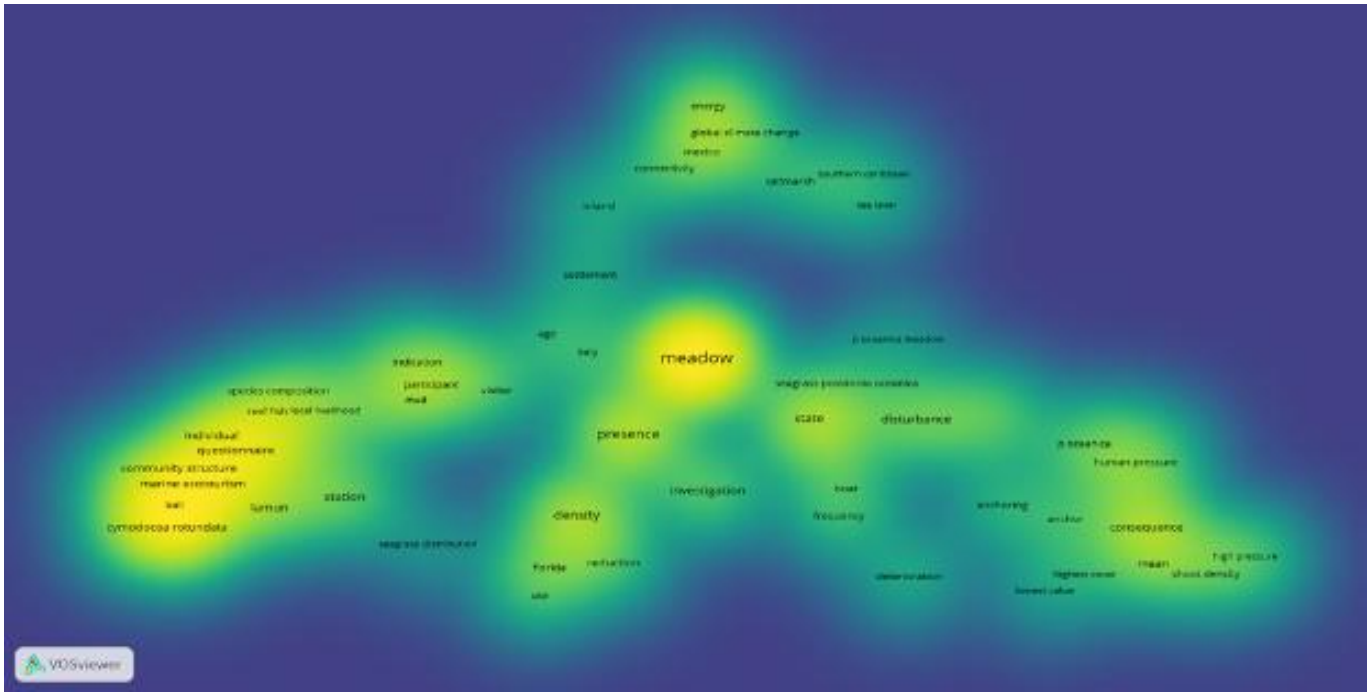

Figure 3. Density heatmap indicating research concentration patterns .

Based on an in-depth literature synthesis, Table 2 summarizes four areas of strategic gaps that represent opportunities for future research. These data reveal a significant disparity between the urgency of global issues and the volume of available publications.

Table 2. Research Gaps and Future Research Needs

Research Gap	Current Coverage	Future Research Needs
Climate-Tourism Integration	9% of articles	Measuring the synergy between tourism rates and carbon financing (Blue Carbon).
Technology & Monitoring	3% of articles	Development of real-time impact detection systems based on IoT or Citizen Science.
Geographic Diversity	Centralized (Indonesia 41%, Mediterranean 22%)	Adaptive models for underrepresented regions in Africa, the Caribbean, and the Pacific.
Policy Governance	7% of articles	Analysis of the effectiveness of co-management institutions at the site level.

Literature analysis reveals a fundamental gap in system and technology integration, where climate and tourism topics are still treated separately. Research linking carbon financing mechanisms to tourism accounts for only 9% of total articles, highlighting the urgent need to develop models that synergize tourism tariffs as a source of carbon credit financing. A similar lag occurs in technology, where the use of advanced instruments in seagrass management is found in only 3% of the literature. The majority of monitoring still relies on manual methods, even though the implementation of IoT-based real-time detection systems or Citizen Science is urgently needed to accurately monitor the impact of tourism activities (Macreadie *et al*., 2021; Buhalis, 2020).

In addition to technical limitations, strong biases were also found in geographical coverage and governance evaluation. Current global research is dominated by case studies from Indonesia (41%) and the Mediterranean (22%), resulting in a lack of comparative data from other tropical regions and limiting the testing of the universality of community-based management models in different socio-cultural contexts. This problem is exacerbated by the superficiality of policy analysis, with only 7% of research evaluating the effectiveness of rule implementation in the field. Therefore, future research should shift from merely analyzing legal documents to evaluating the performance of co-management institutions at the site level (Bennett & Dearden, 2014). Empirical Evidence: The Case Study of Indonesia

Indonesia contributes 41% of global literature, with key findings from the following locations: Sekotong, Lombok: Research shows a double threat from gold mining (mercury) and tourism (Putra *et al*., 2023). However, the potential for integrating the Local Ecological Knowledge (LEK) of fishermen who are familiar with seagrass seasons ("Lamun Kaken" vs "Lamun Pupak") for tourism zoning management has been identified (Syukur, 2013; Rahfika *et al*., 2024). Raja Ampat & Berau: Keberhasilan mekanisme Badan Layanan Umum Daerah (BLUD) di Raja Ampat memungkinkan retensi 100% pendapatan wisata untuk patroli konservasi, sebuah model yang kini direplikasi di Berau untuk skema Karbon Biru (Atmodjo *et al*., 2017; YKAN, 2024).Bibliometric findings confirm that we are witnessing an ontological transition. The old paradigm (Clusters 1 & 2) views seagrass as a biological object separate from humans, or a victim of human activity. The new paradigm (Cluster 3) views seagrass as part of an integrated socio-ecological system (Folke *et al*., 2016; Cullen-Unsworth *et al*., 2014).

In the regenerative paradigm, tourism is no longer seen as the enemy of conservation. The case of Raja Ampat proves that tourism entrance fees (*environmental fees*) can be a key fiscal instrument for maintaining ecological integrity (Mangubhai *et al*., 2012). This debunks the myth that conservation always requires external philanthropic funding; the tourism market itself can finance it if it is properly managed (BLUD). The biggest research gap found is the lack of integration between tourism and the carbon market (only 9% of articles). In fact, this is the biggest opportunity for innovation in Indonesia. With the Carbon Economic Value (NEK) regulation, tourism operators such as Misool Eco Resort or the CarbonEthics initiative can sell "carbon credits" from seagrass restoration to the voluntary market or corporations (CarbonEthics, 2024; The Sea People, 2023). This creates a hybrid business model: income from guests (short term) and income from carbon sequestration (long term). This addresses the financial vulnerability of coastal communities, which often depend on a single source of income (Idrus, 2022; Herr *et al*., 2017).

Advanced technology is not the only solution. Studies in Sekotong confirm that local fishermen's knowledge of seagrass biological cycles is often more accurate and real-time than satellite data (Lam *et al*., 2020; Syukur *et al*., 2021). Ignoring ILK in tourism management is a fatal mistake that often occurs in top-down approaches. The regenerative model requires the involvement of the community not as objects, but as "local experts" who are paid to guide zoning and monitoring (Kodir, A *et al*., 2020). Although the concept is strong, implementation is hampered by governance structures. Many local governments in Indonesia have not dared to implement BLUD status due to bureaucratic complexity, so tourism revenues still "leak" to the center and do not return to the sea (YKAN, 2025). In addition, active restoration (gardening the sea) has a high failure rate if it is not based on solid science (Van Katwijk *et al*., 2016). Therefore, collaboration between scientists (Cluster 1), tourism practitioners (Cluster 2), and socio-economic experts (Cluster 3) is an absolute prerequisite.

CONCLUSION

This study confirms that global seagrass management is undergoing a fundamental paradigm shift, transitioning from

the rigid era of "Defensive Conservation" to an inclusive "Market-Based Regeneration" model. Through bibliometric analysis, it was found that the focus of research has moved from mere bio-physical inventory to socio-economic integration that positions tourism as a funding solution, not just a threat. Although Indonesia leads in terms of global research quantity (41%), implementation in the field still faces governance challenges. This study concludes that the success of the regenerative model depends on the synergy of three key elements: (1) Adoption of Regional Public Service Agency (BLUD) status by local governments to ensure the financial independence of conservation areas; (2) Integration of Blue Carbon and Citizen Science mechanisms by tourism operators to create economic added value as well as ecological data; and (3) Incorporation of local knowledge (ILK) in management zoning. Future research is recommended to fill gaps in the development of inexpensive IoT-based monitoring technology and hybrid economic valuation between tourism tickets and carbon credits.

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