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Review Article

A Bibliometric Review of Seagrass Research in the Philippines (2014–2024): Trends, Disciplinary Focus, and Future Directions

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Abstract: Seagrass ecosystems contribute significantly to both ecological stability and economic resilience. They serve as crucial feeding habitats for dugongs, nurseries for young marine organisms, and significant natural carbon sinks that help mitigate climate change. Despite their importance, seagrass habitats face a range of natural and anthropogenic threats. Previous review papers highlighted regional knowledge gaps in seagrasses across Southeast Asia. However, these studies lack country-specific insights, which is important in developing strategies to address unique issues within a country. This review focuses on generating localized knowledge and providing insights vital for country-specific policies and management strategies. It evaluates trends in seagrass research in the Philippines from 2014 to mid-2024, retrieved from Google Scholar using the keyword “seagrass studies in the Philippines.” The collected articles were compiled in Microsoft Excel for analysis. A total of 123 published articles were identified, a significant increase compared to the last two to three decades. Most publications consist of research articles, followed by reviews and notes. Geographically, Mindanao is the most studied region, with natural sciences emerging as the dominant discipline. Ecology receives the most attention, while physiology, biology, and molecular studies remain significantly underexplored, highlighting the need for further research in these fields. Collectively, seagrass research trends in the Philippines show temporal fluctuations, possibly influenced by external factors that cause periodic increases and decreases in output. Directing research efforts toward underexplored areas is recommended for adaptive management of seagrasses.

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1. Introduction

Seagrass ecosystems offer numerous ecological and economic benefits and are essential to the well-being of coastal and marine environments (Maabuat et al., 2023). According to reports, it is the

main feeding habitat for dugongs and acts as a nursery for diverse marine organisms, offering refuge and food to young fish and invertebrates (Fortes, 2018; Espadero et al., 2020; Ordonio et al., 2020; Capin et al., 2021; Mascariñas, 2022). Additionally, aboveground seagrass biomass significantly influences variation in epifaunal assemblage structures (Leopardas, 2015; Reyes et al., 2022; Reyes et al., 2023). Based on the research findings of Fourqurean et al. (2012), seagrass meadows are a major natural carbon sink in the ocean and play an effective role in mitigating global warming and climate change. Despite their importance, seagrass habitats face threats from various natural and anthropogenic sources (Brodie et al., 2020; Gaboy et al., 2022; Mascariñas and Otadoy, 2023a; Arriesgado et al., 2024b; Celmar et al., 2024).

Similarly, Ooi et al. (2011) and Fortes et al. (2018) conducted comprehensive reviews that highlighted knowledge gaps in seagrass research across Southeast Asia. Their work provides broad insights applicable to large areas, focusing on regional research that offers taxonomic data, research output, and trends across the region. However, the scope of their studies is broad and generalized, leading to thematic trends that are not country-specific or deeply explored at the national level. In-depth national reviews are crucial for generating localized knowledge and providing insights vital for formulating country-specific policies and management strategies (Korinek and Ramdoo, 2017; Hemraj, 2020). This study emphasizes country-specific research, thereby reinforcing ongoing regional initiatives. It also guides future scientific investigations, conservation strategies, and policy development to reflect the nation's distinct ecological characteristics.

This review aims to provide a country-specific overview of seagrass research trends in the Philippines over the last decade (2014-2024) and identify potential future research directions. All articles were sourced from Google Scholar using the keywords "seagrass studies in the Philippines".

The literature search was conducted in July 2024, targeting publications from 2014 to 2024, sorted by relevance. Both open-access and non-open-access articles were considered, provided they met the following inclusion criteria: (1) seagrass-related content, (2) research conducted within the Philippines, and (3) published in English. Peer-reviewed and non-peer-reviewed works were included, while conference abstracts, book chapters, and unpublished materials were excluded to uphold data integrity. Eligible articles were manually compiled into a Microsoft Excel sheet. Each article was categorized by publication type (e.g., research, review, short notes), study location (Luzon, Visayas, Mindanao), research discipline (e.g., natural sciences, social sciences, formal sciences, multi-discipline), and thematic research area (e.g., ecology, biology, physiology, conservation, anthropogenic impacts, molecular studies). Categories were assigned after a thorough review of each article's abstract, introduction, objectives, and stated purpose. Coding was conducted manually by the first and secondary authors, and the senior authors independently validated a subset of articles to ensure classification accuracy.

2. Types of Paper

A total of 123 seagrass-related articles were identified from Google Scholar, covering studies conducted in the Philippines between 2014 and mid-2024. This marks a substantial growth in publication output compared to earlier compilations. For instance, Ooi et al. (2011) documented roughly 65 seagrass-related studies across Southeast Asia using ISI Web of Science. Similarly, Fortes et al. (2018) recorded fewer than 20 articles from the 1980s, around 40 from the 1990s, approximately 60 from the 2000s, and fewer than 70 from 2010 onwards, specifically focusing on the Philippines.

As shown in Figure 1, the majority of the publications were research papers (88%), followed by review articles (11%) and short notes (1%). The dominance of research papers highlights an intensified scientific focus on understanding seagrass ecosystems, largely driven by the ongoing decline in their populations (Orth and Heck, 2023). Although fewer in number, review papers demonstrate the discipline's maturity, offering critical syntheses that reveal patterns, debates, and emerging themes within the field (York et al., 2017; Snyder, 2019). Meanwhile, the small number of short notes suggests that seagrass research is well developed, with most topics thoroughly discussed in detailed publications. Short notes mainly provide preliminary insights that could lead to more in-depth studies (Simon, 2014).

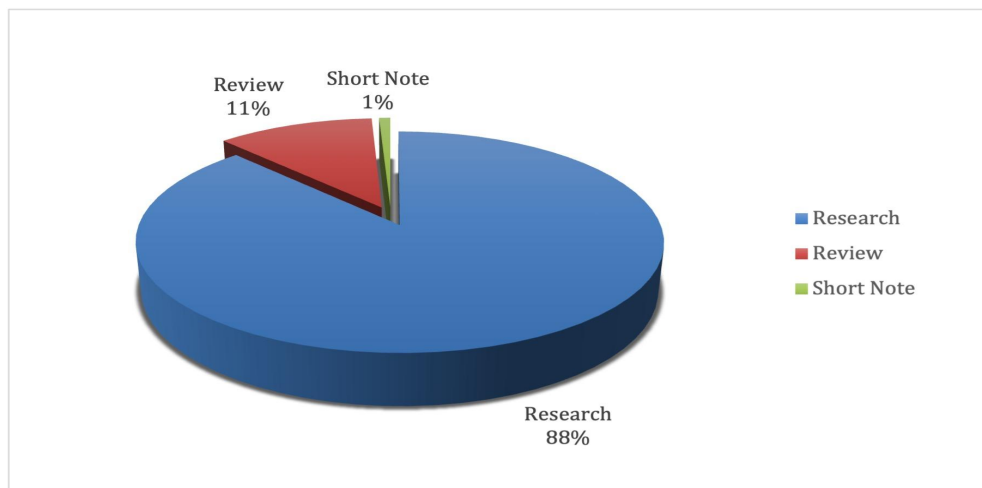


Figure 1. Types of published papers on seagrass over the last decade.

3. Geographic Distribution and Research Disciplines in Seagrass Studies

Mindanao emerged as a major research focal point, accounting for 27.64% of the studies, likely due to its rich seagrass biodiversity or active scientific initiatives in the region. Luzon and Visayas were also prominent areas, demonstrating their critical roles in national conservation efforts. Notably, 20% of the reviewed papers did not specify a geographic location, largely because they were synthesis studies with a national scope. Despite these regional contributions, a noticeable absence of cross-island or connectivity-focused research reveals a significant gap in understanding ecosystem-level interactions. Limited attention to seagrass connectivity and broader spatial dynamics overlooks important ecological insights such as current-driven dispersal or environmental gradients that influence seagrass health and resilience (Nakajima et al., 2014; Arriesgado et al., 2015 and 2016; Kurokochi et al., 2016; Nakajima et al., 2017; Nakajima et al., 2023). Bridging this gap is essential to designing holistic conservation and restoration strategies that reflect the interconnected nature of marine ecosystems.

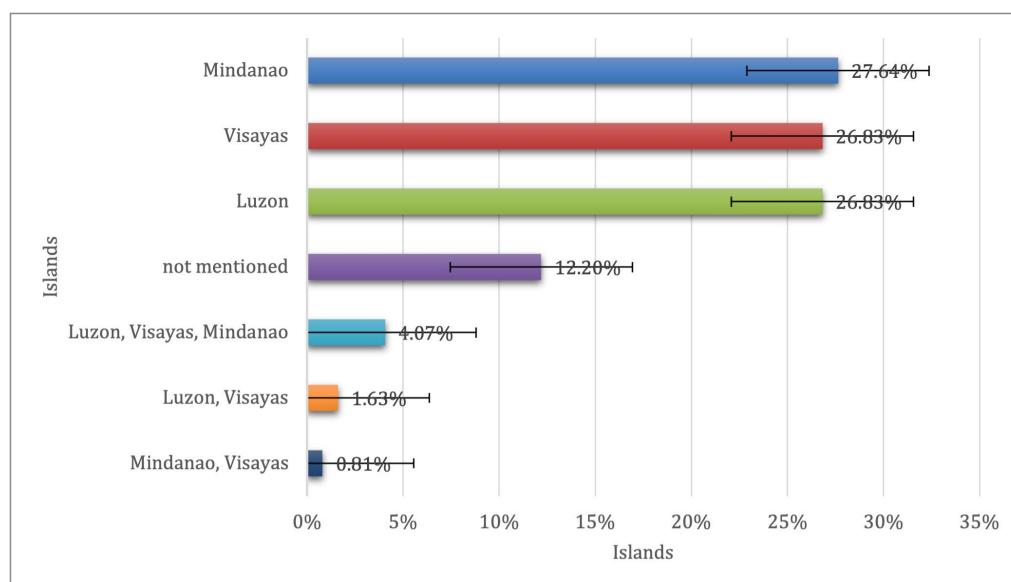


Figure 2. Distribution of seagrass-related papers across different islands in the Philippines over the last decade.

The majority of seagrass studies fall within the natural sciences, reflecting a dominant emphasis on the biological, ecological, and environmental dimensions of seagrass ecosystems (Figure 3A). While multidisciplinary approaches are present, their underrepresentation suggests limited integration across

fields. Social sciences, which are concerned with human-environment interactions, socio-economic implications, conservation efforts, and blue carbon dynamics, are notably scarce. This gap hampers a full understanding of how communities perceive, manage, and benefit from seagrass habitats (Cullen-Unsworth et al., 2014; Grimm et al., 2023; Mascariñas and Otadoy, 2023b). The lack of research in this area may contribute to misaligned conservation policies and reduced adoption due to insufficient consideration of local needs and stakeholder engagement (Bennett et al., 2017). Formal sciences account for only 4% of total studies and often involve mathematical, computational, or statistical methodologies. The absence of such research, particularly in Visayas (Figure 3B), restricts the development of predictive models and quantitative frameworks for evaluating seagrass dynamics (Llabrés et al., 2022). These analytical tools are essential for creating robust, data-driven conservation strategies that address both ecological complexity and socio-economic realities (Dominguez-Tejo et al., 2016; Masaya et al., 2017; Bongolan et al., 2019). Overall, the current trend signals an urgent need for broader disciplinary inclusion to support a comprehensive understanding and management of seagrass ecosystems.

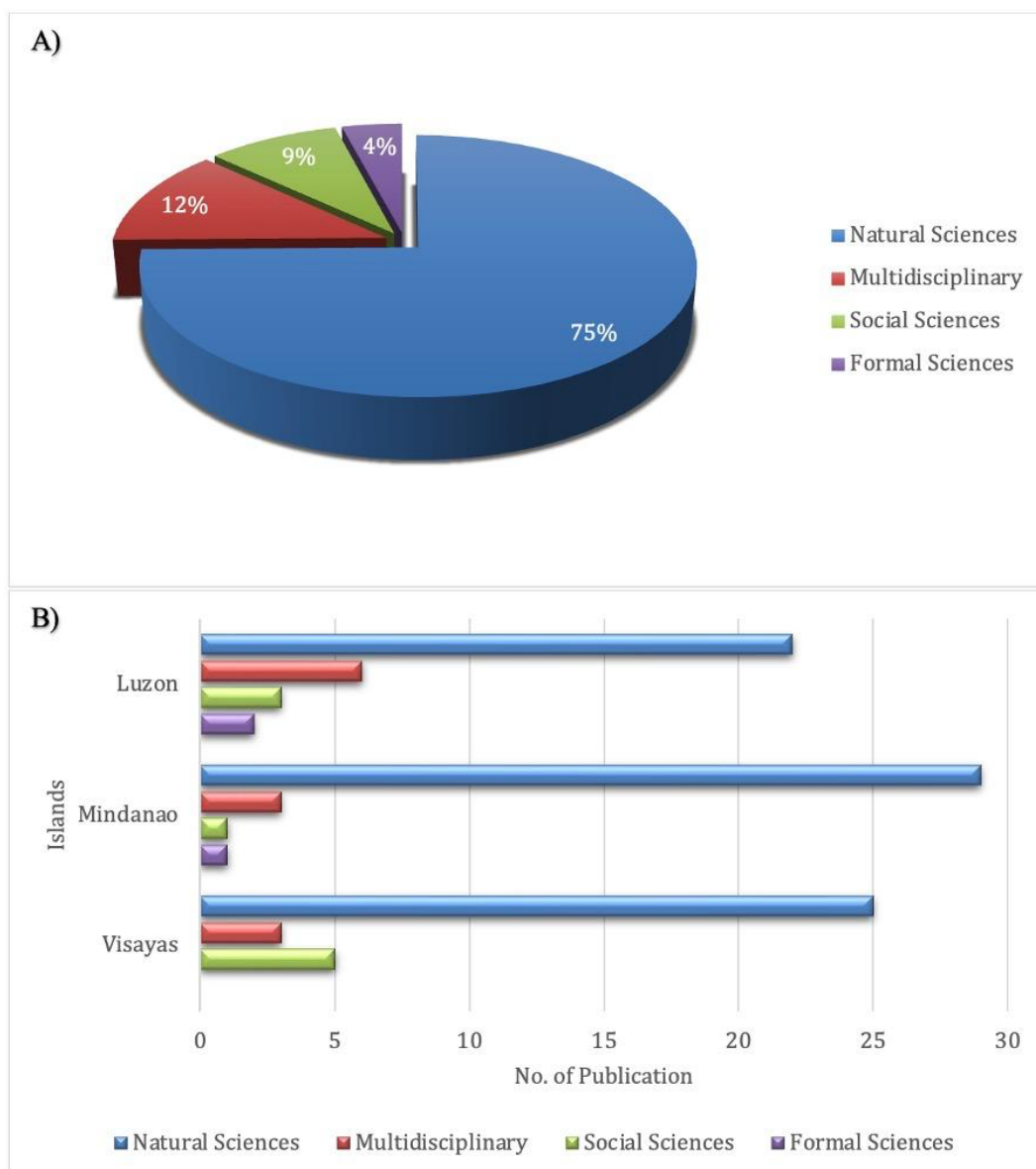


Figure 3. The proportional distribution of disciplines in seagrass research published over the last decade, (A) in the Philippines, (B) within the 3 islands, Luzon, Visayas, and Mindanao.

4. Research Areas in Seagrass Studies and Trends Across Disciplines

The dominant emphasis on ecological studies (42%) reflects the foundational role of ecology in understanding seagrass ecosystem functions, species interactions, and habitat dynamics. This strong focus contributes significantly to building baseline knowledge essential for conservation, management, and the prediction of spatial responses to environmental stressors (Short et al., 2007; Arriagado et al., 2024a). However, the relatively limited number of studies in physiology, biology, and molecular science, 8% and 7%, respectively. It highlights critical gaps in understanding the mechanistic processes underlying seagrass resilience and adaptation. These underexplored domains are vital for revealing physiological responses, genetic variability, and molecular pathways that govern seagrass survival under shifting environmental conditions (Arriagado et al., 2015; Fortes et al., 2018; Arriagado et al., 2023).

The disparity between ecological and mechanistic studies underscores the need for a more integrative research approach that bridges foundational ecosystem knowledge with molecular and physiological insights. Without this synthesis, adaptation strategies may remain speculative and incomplete, particularly in the context of climate change and anthropogenic pressures (Duarte et al., 2018; Pazzaglia, 2022). In biodiversity-rich regions such as the Philippines, closing these disciplinary gaps is especially urgent. Region-specific physiological and genetic data can inform targeted management strategies, guide conservation policies, and foster resilience tailored to local ecological and socio-political conditions (Fortes, 2018; Pazzaglia, 2022).

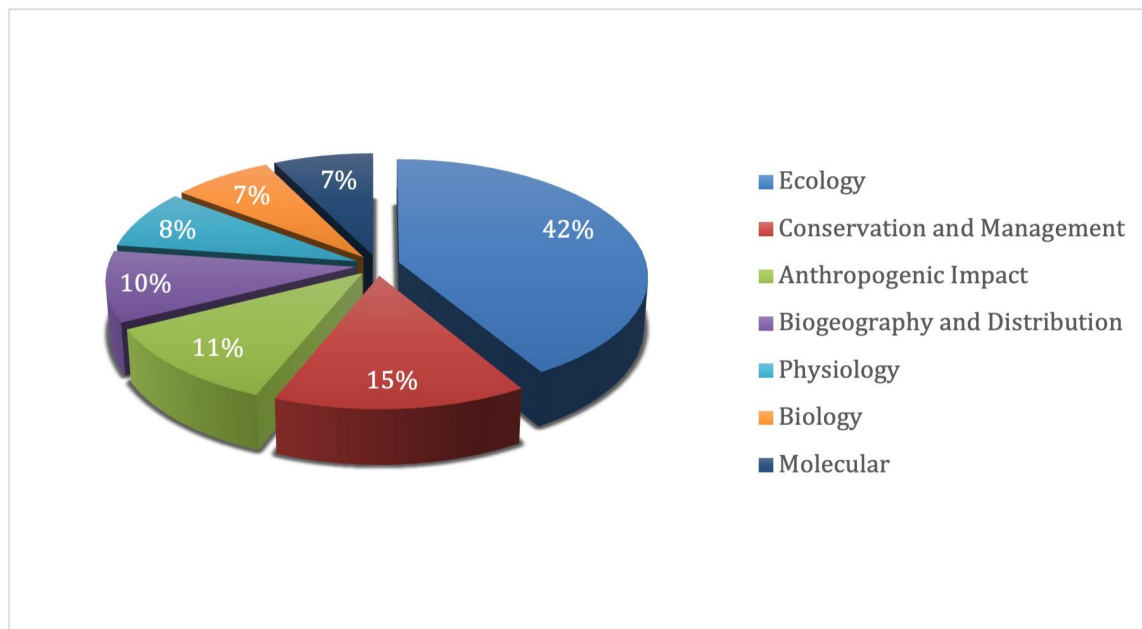


Figure 4. The distribution of research areas over the last decade.

Figures 5A to 5D illustrate the dominant thematic areas within each research discipline. Ecology emerges as the prevailing focus across both natural sciences and multidisciplinary studies (Figures 5A and 5B), highlighting a persistent emphasis on ecosystem dynamics, species interactions, and habitat functions. This ecological prominence underscores its foundational role in informing broader conservation and management strategies (Turner et al., 2017). In the social sciences category (Figure 5C), conservation and management constitute the central research themes. This trend reflects a growing recognition of socio-ecological interdependencies and the need to translate ecological insights into actionable policies that address community needs and promote sustainable resource governance (Fortes, 2018). Within the formal sciences (Figure 5D), biology emerges as the leading thematic area. This focus indicates an investment in fundamental research, including genetic, physiological, and structural analyses of seagrass species. Such studies are vital for elucidating resilience mechanisms and adaptation pathways, particularly under stressors such as climate change and habitat degradation (Phair, 2018).

Collectively, these disciplinary patterns provide valuable insight into the current orientation of seagrass research in the Philippines. While the robust presence of ecological studies offers a strong

scientific foundation, the relative underrepresentation of mechanistic and social dimensions signals opportunities for more integrative, transdisciplinary inquiry.

The results presented in this review serve as a strategic guide for researchers, policymakers, and funding institutions to identify areas of robust scholarly coverage versus those requiring deeper investigation (Fortes, 2018). For example, the evident scarcity of studies on the socioeconomic dimensions of governance signals an urgent need to explore how human communities interact with and influence seagrass ecosystems. Addressing this gap could substantially improve the design and adoption of locally responsive management policies. Moreover, the analysis highlights opportunities for interdisciplinary collaboration by pinpointing thematic intersections across ecological, social, and formal science domains. Such integrative approaches are vital for unraveling the complex interactions between biophysical processes and human activities in seagrass environments. Ultimately, bridging disciplinary divides fosters a more holistic framework for seagrass research, conservation, and sustainable management. Balancing ecological investigations with insights from social sciences and formal methodologies ensures that research outputs are both scientifically rigorous and socially relevant, meeting the multifaceted demands of effective coastal stewardship (Cullen-Unsworth et al., 2014; Fortes, 2018; Grimm et al., 2023; Quevedo et al., 2023).

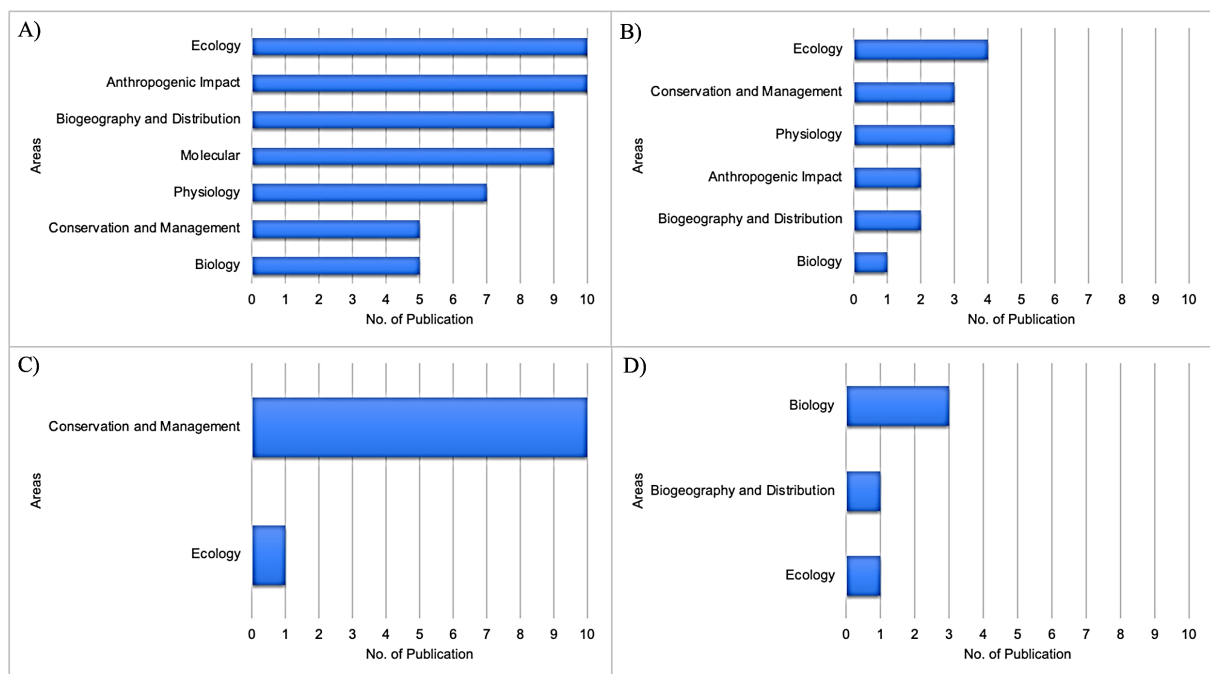


Figure 5. Dominant research areas in different disciplines. (A) natural sciences, (B) multidiscipline, (C) social sciences, (D) formal science.

5. Decadal Trends of Seagrass Publications in the Philippines

The increasing number of seagrass-related publications in the Philippines from 2014 to 2024 indicates growing scientific engagement, likely spurred by heightened environmental awareness and biodiversity conservation efforts (Figure 6). Notable peaks in publication volume in 2015 and 2023, each comprising 16 studies, may reflect surges in research attention driven by global interest in marine ecosystem services. Conversely, troughs observed in 2016 and from 2019 to 2022 suggest periods of disruption, potentially linked to funding constraints, environmental events, or shifts in global conservation priorities (York et al., 2017; Unsworth et al., 2018). The COVID-19 pandemic likely compounded these challenges, contributing to lower outputs. The sharp decline in 2024, with only four studies so far, may be attributed to mid-year data limitations, with potential for increased publications toward year-end. These cyclical patterns highlight critical opportunities for targeted interventions. Understanding the temporal dynamics of research output can inform the strategic allocation of funding, guide national research priorities, and ensure sustained investment in seagrass ecosystem studies (Saunders et al., 2024). Importantly, the observed fluctuations serve not only as benchmarks for progress

but also as a lens for identifying challenges, directing future inquiry, and reinforcing long-term commitment to conservation. By anchoring policy and research frameworks in these insights, stakeholders can promote more adaptive, resilient, and effective management of Philippine seagrass ecosystems (Fortes, 2018; Unsworth et al., 2019; Grimm et al., 2023; Quevedo et al., 2023).

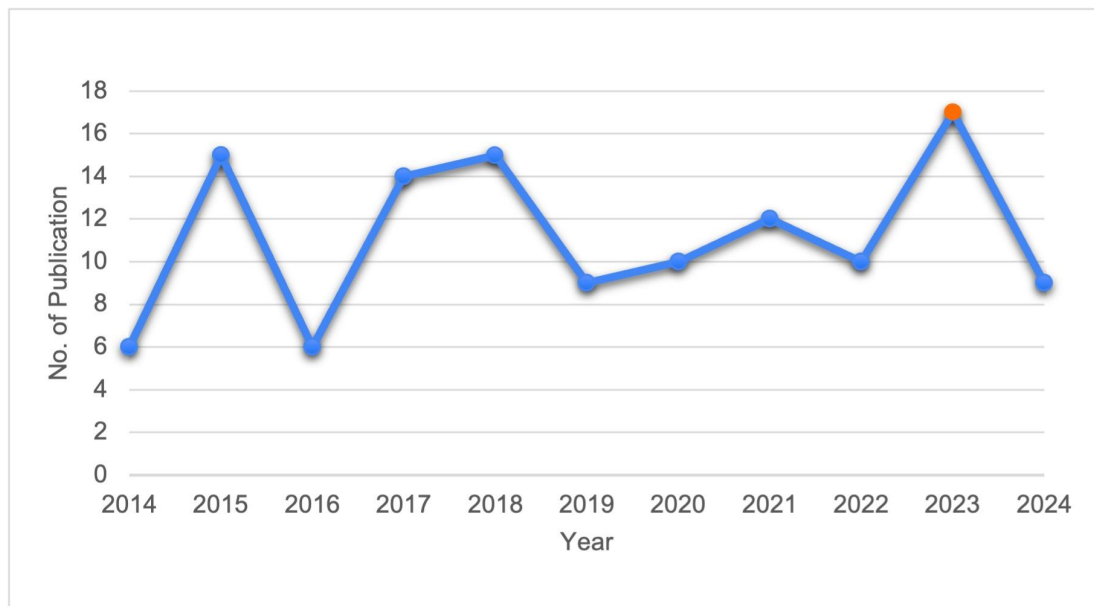


Figure 6. Decadal trends of seagrass publication.

As illustrated in Figure 7, ecological research on seagrasses in the Philippines demonstrates periodic surges in output across the last decade, most notably in 2015, 2017, 2021, and 2023. These peaks reflect a sustained and intensifying interest in the ecological functions of seagrass ecosystems, including their roles in carbon sequestration, habitat provision, and overall ecosystem service delivery (Thorhaug et al., 2020; Stankovic et al., 2021; Arbilo et al., 2023). Fortes (2021) attributes this upward trend to increasing global awareness of climate change, while John et al. (2023) underscore the strategic value of seagrasses for climate mitigation and coastal resilience.

In contrast, the conservation and management domain experienced an early growth phase peaking in 2017, followed by subsequent fluctuations. This temporal pattern echoes broader international conservation movements, such as United Nations Sustainable Development Goal 14, which advocates protecting marine ecosystems (UN, 2017; Rossi, 2022). The observed decline in outputs may signal underlying challenges, such as socio-political barriers and constrained funding streams, that hinder the translation of ecological insights into actionable management practices (Bertuol-Garcia et al., 2018; Mair et al., 2018; Saunders et al., 2024).

The trajectory of research on anthropogenic impacts reveals a modest rise followed by a decline after 2018. Early interest appears to be driven by heightened awareness of human-induced stressors, coastal development, pollution, and eutrophication that degrade seagrass habitats (Waycott et al., 2009). The subsequent decrease may signal a shift in scholarly emphasis toward restorative strategies and solutions-based science, reflecting a more proactive response to environmental degradation. Biogeography and distribution have maintained a relatively low yet stable research output from 2020 to 2022. This consistency may stem from a broadly established understanding of global seagrass distribution patterns, suggesting less urgency for exploratory work. However, sustained attention in this field may also reflect ongoing interest in tracking spatial shifts driven by climate change and coastal transformation, critical for forecasting ecosystem vulnerability and resilience. Physiology exhibits a fluctuating pattern, with a noticeable decline in recent years. This trend may reflect logistical challenges, as physiological research often demands controlled laboratory conditions and long-term experimentation to capture nuanced responses to environmental stressors (York et al., 2013; Duarte et al., 2018). Despite these barriers, physiological insights remain vital for understanding species-level adaptations and tolerance thresholds, which underpin predictive frameworks and climate resilience strategies (e.g.,

Santacera et al., 2015; Wagey, 2015; Watai et al., 2015; Vinson et al., 2016; Yamamoto et al., 2019; Yoshikai et al., 2021; Tiquio, 2024).

Despite the foundational importance of genetic and physiological research, biology and molecular studies remain among the least explored areas in Philippine seagrass scholarship over the past decade. This trend is likely driven by the technical and financial challenges of marine genetic research, including the need for specialized equipment, advanced laboratory facilities, and long-term sampling protocols. However, recent research underscores the pivotal role of genetic diversity in enhancing seagrass resilience against environmental stressors, such as ocean warming, pollution, and habitat fragmentation (Arriesgado et al., 2015; Arriesgado et al., 2016; Arriesgado et al., 2023). By understanding the molecular underpinnings of adaptation and species variability, researchers can develop more targeted and effective conservation interventions. In a region as ecologically diverse as the Philippines, expanding research in biology and molecular science is not only scientifically essential but also vital for designing localized, genetically informed strategies to safeguard seagrass ecosystems. Encouraging investment in this field can lead to breakthroughs in species restoration, assisted adaptation, and long-term genetic monitoring, bridging gaps between ecological theory and conservation practice (Fortes et al., 2018; Pansini et al., 2022; Arriesgado et al., 2023).

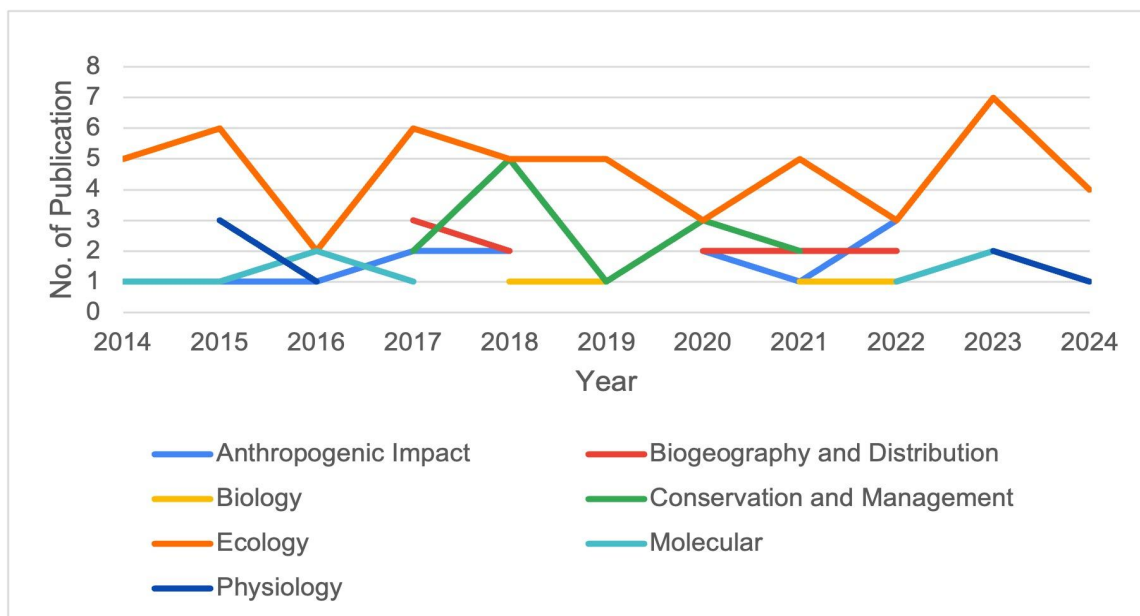


Figure 7. Trends of seagrass publications in various research areas.

6. Conclusion

The bibliometric review reveals a steady increase in seagrass studies in the Philippines from 2014 to mid-2024. It highlights a growing scientific engagement with this critical marine ecosystem. The majority of papers published are research articles, with the natural sciences dominating the disciplinary focus, particularly in ecological research. However, there is significantly less interest in physiology, biology, and molecular research areas, highlighting a need for more research in these areas, as well as in the formal sciences. Temporal fluctuations in research output indicate that external factors, including policy shifts, funding cycles, and global events, influence seagrass studies in the Philippines.

Seagrasses are widely recognized for their ecological versatility and essential role as ecosystem engineers, capable of enhancing sediment stability, supporting benthic communities, and improving water clarity by filtering particles and promoting nutrient cycling. Their ability to photosynthesize contributes oxygen, increases pH, and helps mitigate ocean acidification, while their capacity to store carbon positions them as nature-based solutions to climate change. These ecosystem services highlight the urgency of conserving and restoring seagrass habitats as part of the Philippines' broader strategy for coastal resilience and sustainable marine management.

To reinforce these ecological benefits, we recommend enhanced investment in transdisciplinary research that deepens physiological, biological, and molecular insights. Expanding the social sciences is equally vital for better understanding human-seagrass dynamics, local knowledge systems, and community-based conservation. Likewise, integrating formal sciences, such as statistics, modeling, and computational simulation, can provide tools for forecasting ecosystem shifts and informing evidence-based policy decisions.

It is important to acknowledge study limitations, particularly the exclusive use of Google Scholar, omission of full-text analysis, and reliance on English-language sources. These constraints may have led to the exclusion of relevant local studies and non-indexed grey literature, suggesting that future reviews would benefit from a more inclusive and multilingual database strategy.

Ethical Statement

Ethical approval is not required for this study because it does not directly involve humans or animals.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Author Contributions

The research idea was formulated by author 1, and articles were coded by author 2. The manuscript was written by authors 1 and 2, with proofreading and methodological guidance from authors 3, 4, and 5.

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