

Implementation of SDG 14 and Blue Economy Policies in Southeast Asia: A Comparative Policy Review

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SDG 14 and Blue
Economy Policies

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ABSTRACT

This study explores the implementation of Sustainable Development Goal (SDG) 14 and blue economy policies across Southeast Asia, focusing on seven key indicators: protection of marine Key Biodiversity Areas (KBAs), waste management effectiveness, exploitation of fish stocks, use of destructive fishing gear, bycatch levels, marine biodiversity threats from imports, and national/regional policy efforts. Using a qualitative descriptive approach and secondary data analysis from international reports, national regulations, and scholarly sources, the study uncovers stark disparities among countries. High-capacity states like Indonesia, Malaysia, and Singapore have made measurable progress, whereas Least Developed Countries (LDCs) such as Laos, Cambodia, and Myanmar face significant implementation challenges due to limited financial, technological, and institutional resources. Findings indicate that overfishing, ineffective enforcement of trawling bans, lack of incentives for selective fishing gear, and ecological degradation from aquaculture expansion remain major concerns. However, emerging policy innovations such as Indonesia's Sea Toll initiative, the Philippines' coral reef ecotourism, and Singapore's carbon taxes offer potential models. Still, these efforts are insufficient without greater regional harmonization, capacity building, and strategic resource redistribution. This study emphasizes the urgency of coordinated regional action, enhanced policy coherence, and inclusive support mechanisms to realize a sustainable, equitable, and resilient blue economy in Southeast Asia.

Keywords: Blue Economy, Marine Biodiversity, SDG 14, Southeast Asia, Sustainable Fisheries.

ABSTRAK

Penelitian ini mengkaji implementasi Tujuan Pembangunan Berkelanjutan (TPB) 14 dan kebijakan ekonomi biru di kawasan Asia Tenggara, dengan fokus pada tujuh indikator utama: perlindungan Kawasan Bernilai Keanekaragaman Hayati Tinggi (KBAs) laut, efektivitas pengelolaan limbah, tingkat eksploitasi stok ikan, penggunaan alat tangkap merusak, tingkat tangkapan sampingan (bycatch), ancaman terhadap keanekaragaman hayati laut akibat impor, serta kebijakan nasional dan regional yang relevan. Menggunakan pendekatan kualitatif deskriptif dan analisis data sekunder dari laporan internasional, regulasi nasional, serta literatur akademik, studi ini menemukan adanya kesenjangan signifikan antarnegara. Negara-negara dengan kapasitas tinggi seperti Indonesia, Malaysia, dan Singapura menunjukkan kemajuan nyata, sedangkan negara-negara berkembang seperti Laos, Kamboja, dan Myanmar menghadapi tantangan besar akibat keterbatasan sumber daya finansial, teknologi, dan kelembagaan. Temuan menunjukkan bahwa praktik penangkapan ikan yang berlebihan, lemahnya penegakan larangan trawl, kurangnya insentif untuk penggunaan alat tangkap selektif, dan degradasi ekologis akibat ekspansi budidaya perikanan masih menjadi masalah utama. Meski beberapa inovasi kebijakan mulai muncul seperti inisiatif Tol Laut Indonesia, ekowisata terumbu karang di Filipina, dan pajak

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karbon di Singapura upaya tersebut belum cukup tanpa adanya harmonisasi regional, penguatan kapasitas, dan distribusi sumber daya yang lebih adil. Studi ini menekankan pentingnya aksi regional yang terkoordinasi untuk mewujudkan ekonomi biru yang inklusif, berkelanjutan, dan tangguh di Asia Tenggara.

Kata kunci: *Ekonomi Biru, Keanekaragaman Hayati Laut, SDG 14, Asia Tenggara, Perikanan Berkelanjutan.*

INTRODUCTION

Southeast Asia, a maritime region comprising 11 countries with over 173,000 km of coastline and 8.9 million km² of water area, stands as the epicenter of global marine biodiversity. It harbors 34% of the world's coral reef cover, 35% of mangrove forests, and 28% of seagrass beds (Endo & Ikeda, 2021). These rich ecosystems are not only ecologically significant but also economically vital, supporting the livelihoods, food security, and cultural identities of more than 650 million people. However, despite the region's natural wealth, its marine environment is under severe stress from multiple anthropogenic pressures. According to the ASEAN Report on the State of the Marine and Coastal Environment (2021), over 40% of regional fish stocks have been overexploited, and approximately 8 million tonnes of plastic waste enter Southeast Asian waters annually. These alarming figures underscore an urgent need to implement integrated ocean governance and sustainable marine management policies.

The concept of the blue economy which seeks to harness ocean resources for economic development while ensuring ecological preservation and social inclusivity has gained traction as a strategic solution (Nayak, 2020; Veríssimo et al., 2021). Anchored in Sustainable Development Goal (SDG) 14: "Life Below Water", this approach aims to reduce marine pollution, manage fisheries sustainably, conserve marine ecosystems, and mitigate ocean acidification (Armstrong, 2020; Griggs et al., 2017). However, the effectiveness of SDG 14 implementation across Southeast Asia remains highly uneven. Factors such as institutional fragility, economic dependence on marine industries, and geographic vulnerabilities influence policy enforcement and outcomes (Lee et al., 2020; Choudhary et al., 2021).

For example, Indonesia, the world's largest archipelagic state, relies on marine resources for the livelihood of 60% of its population (Akbar et al., 2022). Yet, the country grapples with widespread Illegal, Unreported, And Unregulated (IUU) fishing and mangrove degradation due to aquaculture expansion (World Bank, 2021). Similarly, the Philippines faces overfishing crises in regions like Visayas (Satizábal et al., 2020), while Vietnam contends with industrial pollution in the Mekong Delta (Huyen, 2021). Least Developed Countries (LDCs) and Small Island Developing States (SIDS) such as Cambodia, Myanmar, and Timor-Leste face dual vulnerabilities: they rely heavily on small-scale fisheries for food security while lacking the institutional capacity for effective marine governance (Sarangi, 2023). In contrast, Singapore, despite its limited sea territory, exemplifies innovation through marine waste treatment and artificial coral reef restoration (Hameed et al., 2021).

The regional response, including ASEAN's Framework Action Plan on Marine Debris, aims to foster cooperation. However, divergent national priorities, border disputes, and policy fragmentation continue to hinder cohesive progress (Harris et al., 2018; Martínez-Vázquez et al., 2021). This fragmented governance results in suboptimal outcomes for SDG 14 targets and blue economy aspirations.

Table 1. SDG Index Rankings in 2024 (Selected ASEAN Countries)

No	Country	SDG Index Ranking (out of 166 countries)
1	Thailand	45 / 166
2	Vietnam	54 / 166
3	Singapore	65 / 166
4	Indonesia	78 / 166
5	Malaysia	79 / 166
6	Philippines	92 / 166
7	Brunei	96 / 166
8	Cambodia	104 / 166
9	Laos	119 / 166
10	Myanmar	120 / 166
11	Timor-Leste	Not Available

Table 1 present a critical research gap emerges in understanding how these SDG 14 indicators are implemented across countries with varying capacities. While prior studies have explored marine governance strategies in Bangladesh, Africa, and the Pacific (Islam & Shamsuddoha, 2018; Okafor-Yarwood et al., 2020; Baker et al., 2023), comparative evaluations within Southeast Asia remain limited. Additionally, much of the existing literature emphasizes either environmental impacts or policy aspirations but lacks integration with empirical SDG 14 metrics such as the Ocean Health Index or indicators on bottom trawling, fish stock collapse, and biodiversity protection (Islam et al., 2024; Peña et al., 2022; Stephenson & Hobday, 2024). Scholars like Sarwar (2022) and Karuppiah et al. (2025) emphasize the urgency of implementing inclusive blue economy models in emerging economies, yet Southeast Asia's unique marine-political mosaic is underexplored in this context. Moreover, the indirect ecological effects of trade such as marine biodiversity threats embedded in imports are rarely assessed (Peña et al., 2022).

Against this backdrop, this research seeks to fill the empirical and comparative gap in assessing the implementation of SDG 14 and blue economy policies across Southeast Asian nations. This study analyzes seven key indicators, namely 1) Mean Area Protected in Marine Sites Important to Biodiversity, 2) Ocean Health Index: Clean Waters Score, 3) Fish Caught from Overexploited or Collapsed Stocks, 4) Fish Caught by Trawling or Dredging, 5) Fish Caught That Are Then Discarded, 6) Marine Biodiversity Threats Embodied in Imports, and 7) National policies addressing SDG 14 and the Blue Economy. By examining country-level efforts from high-capacity actors like Malaysia to LDCs like Laos this study aims to (1) identify implementation disparities, (2) analyze enabling and constraining factors for policy performance, and (3) offer insights into how regional cooperation and national reforms can synergize to advance ocean sustainability. Ultimately, this research aspires to contribute to a more integrated and equitable blue economy transition in Southeast Asia, aligned with global sustainability goals and the unique socio-ecological dynamics of the region.

LITERATURE REVIEW

The SDG Index: A Framework for Measuring Sustainable Development Progress

The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, represent a universal call to action for achieving economic, social, and environmental sustainability by 2030. The SDG Index, developed by the Sustainable Development Solutions Network (SDSN) and the Bertelsmann Stiftung, provides a globally recognized, composite measurement framework to monitor the progress of countries toward achieving these 17 goals (Sachs et al., 2024). It aggregates performance across indicators encompassing dimensions such as poverty, education, health, gender equality, environmental sustainability, and economic growth (Manuel et al., 2018; Endo & Ikeda, 2021).

Conceptually, the SDG Index serves as both a diagnostic and benchmarking tool. It allows countries to assess their standing relative to peers and to identify policy gaps, facilitating targeted interventions (Islam & Shamsuddoha, 2018; Sridharan et al., 2021).

The index incorporates disaggregated data and dashboards to highlight areas requiring urgent attention, enhancing accountability and transparency in governance (Hameed et al., 2021; Sarangi, 2023). Scholars such as Neumann et al. (2017) emphasize its multidimensional nature, linking it to the "strong sustainability" paradigm, where economic development must respect environmental thresholds and social equity. In the Southeast Asian context, the SDG Index has particular relevance. Countries such as Thailand (ranked 45th), Vietnam (54th), and Indonesia (78th) demonstrate varied progress, reflecting different national priorities and capacities. These rankings offer a comparative lens for ASEAN nations to share best practices and align policy reforms. Moreover, the Index indirectly supports regional initiatives such as the ASEAN Framework of Action on Marine Debris and commitments under the blue economy agenda (ASEAN, 2021; World Bank, 2021).

Theoretically, the SDG Index aligns with the systems-thinking approach in sustainability science, which recognizes the interlinkages between sectors and goals (Armstrong, 2020; Baker et al., 2023). As noted by Kolavani and Mather (2025), integrating indices like the SDG Index with sector-specific frameworks, including for SDG 14 (Life Below Water), enhances strategic governance. The Index thereby becomes instrumental in operationalizing sustainable ocean governance and blue economy models in policy discourse (Lee et al., 2020; Kabil et al., 2021; Choudhary et al., 2021).

SDG 14: Conserving Marine Ecosystems and Their Role in Southeast Asia

Sustainable Development Goal 14 (SDG 14), "Life Below Water," aims to conserve and sustainably use the oceans, seas, and marine resources for sustainable development. Its relevance is especially pronounced in Southeast Asia, a region where over 65% of the population lives within coastal zones (Lee et al., 2020). Marine ecosystems provide critical services including food security, livelihoods, coastal protection, and climate regulation, yet face escalating pressures from overfishing, pollution, habitat loss, and climate change (Neumann et al., 2017; Islam & Shamsuddoha, 2018).

SDG 14 includes ten targets ranging from reducing marine pollution and regulating harvesting to enhancing the conservation of coastal ecosystems and increasing economic benefits to Small Island Developing States. Within Southeast Asia, implementation has varied due to differing political, economic, and environmental contexts (Endo & Ikeda, 2021). For instance, Indonesia has established 23.9 million hectares of Marine Protected Areas, while the Philippines and Singapore have focused on coral reef restoration and marine waste management, respectively (Islam et al., 2024). Conversely, Cambodia and Myanmar lag behind due to limited institutional capacity and budgetary constraints (Asadullah et al., 2020; Hameed et al., 2021).

The Blue Economy paradigm serves as a theoretical lens to integrate marine conservation with sustainable development. This concept emphasizes economic development that is ecologically responsible and socially inclusive (Sridharan et al., 2021; Sarangi, 2023). It aligns with SDG 14 by promoting responsible fisheries, marine tourism, and coastal resilience, while acknowledging trade-offs between development and conservation (Armstrong, 2020; Baker et al., 2023). In Vietnam, this is evident in the conflict between conservation zones like Ha Long Bay and industrial expansion in the Mekong Delta (Huyen, 2021).

To assess regional integration of SDG 14, a framework by Sachs et al. (2024) includes seven performance indicators: marine protected areas in biodiversity hotspots, ocean health index (clean waters), status of fish stocks, prevalence of trawling, discarded catch rates, biodiversity risks embedded in imports, and policy responsiveness. These indicators offer a quantitative foundation to evaluate cross-national implementation and reveal governance gaps (Peña et al., 2022; Stephenson & Hobday, 2024).

Ultimately, achieving SDG 14 in Southeast Asia requires not only ecological stewardship but also transboundary collaboration, policy integration, and investment in blue innovation (Rianawati et al., 2024; Kolavani & Mather, 2025; Karuppiah et al., 2025). A justice-based approach to marine governance emphasizing equity, inclusivity,

and ecological integrity is fundamental to SDG 14's long-term success (Armstrong, 2020; Haward & Haas, 2021).

Blue Economy: Integrating Economic Growth with Marine Sustainability

The Blue Economy has emerged as a transformative development paradigm that harmonizes economic advancement with marine ecosystem conservation. Rooted in the ethos of Sustainable Development Goal (SDG) 14 "Life Below Water" the concept advocates the sustainable utilization of ocean resources for economic growth, improved livelihoods, and ecological health (Lee et al., 2020; Armstrong, 2020). It challenges conventional extractive maritime models by promoting integrated strategies that encompass ecological restoration, sustainable resource extraction, and institutional innovation (Stephenson & Hobday, 2024; Narwal, 2024; Nabi & Hayat, 2025).

Blue Economy is multidimensional, integrating ecological economics, environmental justice, and sustainability science. Neumann et al. (2017) emphasize the importance of "strong sustainability" in coastal management, advocating for ecosystem preservation as a non-substitutable asset. The blue economy aligns with such perspectives by embedding conservation imperatives into economic planning (Choudhary et al., 2021). Armstrong (2020) further extends the theoretical discourse with the notion of "ocean justice," linking marine governance to social equity and intergenerational responsibility.

Empirical studies show how ASEAN countries are gradually localizing Blue Economy principles. For instance, Indonesia has initiated satellite-based vessel monitoring and mangrove restoration programs to promote community-based conservation and reduce illegal fishing (World Bank, 2021; Akbar et al., 2022). Singapore's investment in eco-maritime ports and waste-to-energy infrastructure illustrates technological pathways toward reducing marine pollution while fostering economic competitiveness (Kabil et al., 2021; Rianawati et al., 2024). Yet, implementation disparities persist across the region due to fiscal limitations, fragmented policies, and institutional inertia (Endo & Ikeda, 2021; Hameed et al., 2021).

The Blue Economy's policy framework increasingly relies on tools like marine spatial planning, ecolabel certification, and regional governance platforms to address transboundary marine issues (Sarangi, 2023; Okafor-Yarwood et al., 2020). Integrated approaches such as the ASEAN Framework on Marine Debris are pivotal for addressing plastic pollution and marine biodiversity loss (Sridharan et al., 2021). Previous literature converges on the premise that marine sustainability is inseparable from regional cooperation and policy coherence. This framework supports the current study's inquiry into how nations translate Blue Economy strategies into measurable marine sustainability outcomes. The concept not only serves as a vehicle for SDG 14 but also connects with broader global sustainability transitions, providing a fertile ground for future research on policy alignment, institutional capacity, and inclusive development (Martínez-Vázquez et al., 2021; Peña et al., 2022).

RESEARCH METHOD

This study applies a qualitative descriptive research method aimed at providing an in-depth and contextualized analysis of the state of marine biodiversity protection and policy performance in ASEAN countries. Qualitative descriptive research is particularly suited for studies involving the interpretation of secondary data, including literature and document analysis, to derive patterns, comparisons, and inferences regarding complex issues (Alamsyahbana et al., 2023). The main data used in this research is secondary data, which refers to information gathered from published reports, policy documents,

databases, and scientific literature that are not directly collected from field observations or firsthand sources (Sugiyono, 2021).

The data collection techniques in this research involved two primary approaches: literature study and web searching. The literature study, as defined by Alamsyahbana et al. (2023), entailed a comprehensive review of books, scientific articles, and official documents relevant to the protection of marine biodiversity and policy responses in Southeast Asia. The web search complemented the literature review by accessing up-to-date databases, institutional reports (e.g., Ocean Health Index, Sea Around Us, Birdlife International), and international academic publications.

Data analysis was carried out through content analysis and policy evaluation techniques. First, the data was systematically reviewed to identify dominant themes, such as policy implementation gaps, levels of biodiversity protection, and environmental impacts of fishing activities. This thematic analysis was followed by policy analysis to evaluate how effectively each country's policy frameworks respond to sustainability targets. Data triangulation was employed to cross-validate findings from multiple sources and ensure analytical rigor and reliability.

RESULTS

Protection of Marine Biodiversity Areas in Southeast Asia

The preservation of marine ecosystems plays a critical role in maintaining global biodiversity, particularly in regions with extensive coastlines and rich marine life such as Southeast Asia. One of the key indicators used to evaluate conservation efforts in marine environments is the mean percentage area of marine Key Biodiversity Areas (KBAs) that are protected. Marine KBAs are specific locations identified as being vital for the long-term persistence of marine biodiversity. These areas often contain endemic species, breeding grounds, and unique ecosystems that are highly vulnerable to human activities. Effective protection of these areas is essential for achieving biodiversity targets, ensuring ecosystem resilience, and supporting coastal communities dependent on marine resources.

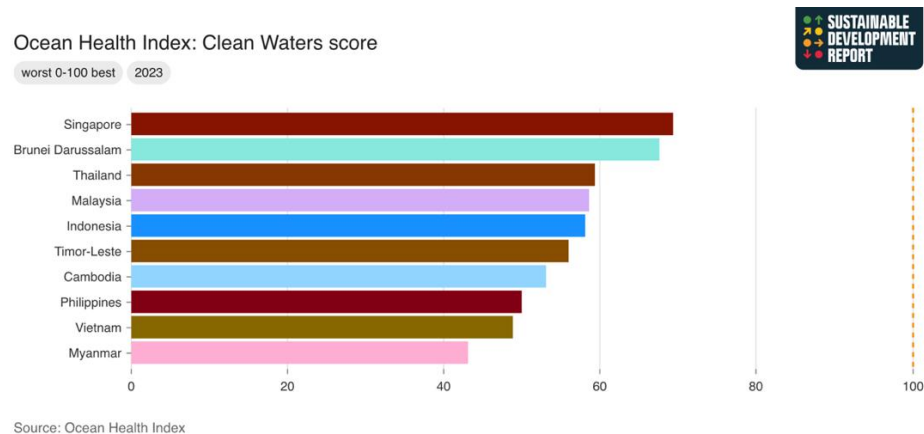


Figure 1. Ocean Health Index

According to Figure 1, data presented in 2023 by Birdlife International and its partners, Southeast Asian countries demonstrate varying degrees of success in protecting their marine KBAs. The data categorizes countries into three broad groups based on the proportion of these areas that are currently protected: high protection (60 to 100 percent), moderate protection (20 to 50 percent), and low protection (less than 20 percent). These groupings offer insight into each country's commitment to marine conservation and their ability to implement and manage Marine Protected Areas (MPAs).

In the high protection category are the Philippines, Indonesia, and Malaysia. These countries have made significant progress in securing their marine KBAs through well-established conservation frameworks, public engagement, and strong regulatory

mechanisms. The Philippines, an archipelago with one of the highest levels of marine biodiversity in the world, has implemented a decentralized approach to marine resource management, empowering local governments and communities to take part in the creation and maintenance of MPAs. Indonesia, recognized as the world's largest archipelagic state, has also prioritized marine conservation as part of its national strategy. The country has designated vast areas as marine reserves and continues to expand its marine spatial planning initiatives. Similarly, Malaysia has adopted marine conservation strategies that focus on coral reef protection, sustainable fisheries, and marine park development. These efforts have led to relatively high levels of marine KBA protection in each of these countries.

Countries in the moderate protection group namely Thailand, Vietnam, and Brunei Darussalam have shown partial commitment to conserving marine biodiversity. While there are protective measures in place, these are often limited in scope or hampered by weak enforcement, limited funding, or conflicting land and sea use priorities. Thailand has developed a number of marine national parks and marine biodiversity projects. However, tourism development and coastal infrastructure expansion have placed pressure on marine environments. Vietnam has made progress in fisheries reform and coastal habitat conservation but continues to struggle with overfishing and pollution. Brunei Darussalam, despite its smaller size and lower population, has implemented conservation efforts but lacks large-scale marine conservation initiatives. These countries illustrate the importance of not only establishing MPAs but also ensuring their effective implementation and long-term sustainability.

In contrast, countries such as Cambodia, Myanmar, Timor-Leste, and Singapore fall into the low protection category. These countries currently protect less than 20 percent of their marine KBAs, a level that is insufficient to preserve ecosystem functions or contribute meaningfully to regional and global conservation targets. Cambodia and Myanmar face significant challenges related to governance, limited technical capacity, and competing development needs. Both countries have substantial coastlines and marine resources, but their efforts to protect biodiversity remain minimal. In Timor-Leste, as a relatively young and developing nation, conservation initiatives are still in the early stages, with support often coming from international partners. Singapore, despite its economic strength and technological capacity, has limited marine KBA protection due to its small marine area and heavy industrial and shipping activities. However, the country has made efforts in localized habitat restoration, such as coral reef rehabilitation and seagrass monitoring.

The variation in marine KBA protection across Southeast Asia reflects broader regional disparities in policy, resources, and environmental priorities. While some countries have established effective marine protection regimes, others lag behind, often due to institutional or economic constraints. This disparity has implications not only for national biodiversity but also for the shared marine ecosystems that cross national boundaries. Transboundary cooperation, regional planning frameworks, and increased funding for marine conservation could help bridge the gap between countries and foster more equitable biodiversity protection across the region.

Achieving higher levels of marine KBA protection in Southeast Asia is essential for meeting international biodiversity goals such as the Convention on Biological Diversity's post-2020 targets and the United Nations Sustainable Development Goal 14. Without expanded and effectively managed MPAs, the region risks losing critical habitats and species that are central to ocean health and human well-being. A unified regional effort, supported by science-based policy, community engagement, and international collaboration, is necessary to ensure the long-term preservation of Southeast Asia's unique and irreplaceable marine biodiversity.

Ocean Health and Marine Pollution: Clean Waters Index Across ASEAN

The mean area protected in marine sites critical to biodiversity varies significantly across Southeast Asian countries. In countries with high marine protection levels, such as

the Philippines, Indonesia, and Malaysia, strong policy frameworks and extensive marine biodiversity have driven conservation efforts. The Philippines, with over 1,800 marine Key Biodiversity Areas (KBAs), including the Tubbataha Reefs Natural Park a UNESCO World Heritage Site leads with 80–90% protection in key areas. Through its National Integrated Protected Areas System (NIPAS), the country emphasizes community involvement in managing protected zones. However, challenges like illegal, unreported, and unregulated (IUU) fishing, particularly in the Sulu and Celebes Seas, persist. Indonesia protects around 70–80% of its key marine areas, including Komodo and Raja Ampat National Parks, covering 23.9 million hectares (as of 2023), with a national goal of 32.5 million hectares by 2030. Yet, weak enforcement in remote zones like the Arafura Sea remains problematic. Malaysia protects 60–70% of its marine biodiversity, especially coral reefs in Sabah and Sarawak, and works regionally through the Coral Triangle Initiative. Still, conservation efforts often clash with offshore oil exploration in the South China Sea.

Moderate protection countries like Thailand, Vietnam, and Brunei Darussalam protect around 20–40% of key marine areas. Thailand's efforts include marine parks like Similan and Surin, backed by programs such as the Andaman Sea Marine Biodiversity Initiative. However, mass tourism in places like Phuket and Krabi strains marine ecosystems. Vietnam focuses protection on Ha Long Bay and the Con Dao Islands but faces serious pollution from industrial waste in the Mekong Delta. Brunei, while maintaining strict conservation policies in areas like Brunei Bay, has limited marine coverage, and growing offshore oil operations threaten mangroves.

Countries with low marine protection, including Cambodia, Myanmar, Timor-Leste, and Singapore, generally protect less than 15% of key areas. Cambodia, for instance, protects only 1.7% of its marine areas, mostly around the Koh Rong Islands. Its budget deficits and focus on land-based development limit conservation investments. Myanmar's conservation is hampered by political instability and widespread mangrove degradation in the Ayeyarwady Delta. Timor-Leste has made modest progress, establishing its first protected area in 2016 (Nino Konis Santana) with support from the *ATSEA-2* program. However, foreign fishing theft in its Exclusive Economic Zone (EEZ) remains a concern. Singapore, despite its advanced policies, protects only 10–15% of marine areas, mainly through artificial reef efforts on Hantu and Sisters' Islands, but sea reclamation and shipping traffic exert pressure on marine habitats.

Only six of the 11 countries meet the global Sustainable Development Goal (SDG) 14 target of 17% marine area protection. The Philippines and Indonesia perform best, integrating Marine Protected Areas (MPAs) into blue economy initiatives like coral reef ecotourism, which contributes 5% to the Philippines' GDP. However, countries like Vietnam and Thailand must balance ecosystem recovery with the need to boost marine exports, while Least Developed Countries (LDCs) like Cambodia and Myanmar require international assistance to build capacity.

In terms of the Ocean Health Index for clean waters, Singapore leads due to strict regulations and effective waste management. Brunei and Thailand follow with moderately strong performance, though tourism and domestic waste remain issues. Countries like Indonesia, the Philippines, and Vietnam struggle with plastic and industrial pollution, while Myanmar ranks lowest due to conflict and weak infrastructure. Key factors influencing water quality scores include the strength of environmental policy, waste management capacity, public environmental awareness, and geographic complexity, especially in archipelagic states.

To improve, Southeast Asian nations should invest in waste treatment infrastructure, promote regional cooperation on transboundary pollution (especially in the South China Sea), and educate communities on reducing plastic use. Stronger law enforcement is also crucial to penalize marine pollution violations.

Fish catch data reveal concerning trends in overexploited or collapsed stocks. Cambodia likely has the highest percentage due to limited regulation and widespread overfishing. Thailand and Malaysia also face high pressure from domestic and export

demands, worsened by the use of destructive gear like trawls. Indonesia and the Philippines have lower rates but remain vulnerable as two of the world's largest fish producers. Vietnam shows the lowest exploitation, although rising market demands may reverse progress. Overfishing is driven by weak enforcement, economic pressures, destructive gear, and climate change impacts on fish habitats.

Recommended strategies include implementing catch quotas, enforcing anti-IUU fishing laws, introducing eco-friendly fishing gear, and educating fishers on sustainable practices. ASEAN-wide collaboration can help manage transboundary fish stocks.

Regarding trawling and dredging practices, Vietnam is likely the most dependent, using intensive methods to meet export targets. Cambodia and Myanmar face similar issues due to weak governance and traditional methods. Thailand and Malaysia also rely heavily on these techniques. In contrast, Brunei, Indonesia, the Philippines, and Singapore have lower reliance, attributed to stricter regulations or small-scale industries. Transitioning away from trawling should involve establishing no-trawl zones, enhancing surveillance, offering eco-friendly subsidies, and setting regional sustainability standards.

Vietnam again likely tops the list for fish discards, reflecting non-selective fishing and inadequate infrastructure. Brunei's high rate may result from limited storage and processing capacity. Indonesia and Myanmar rank high due to widespread destructive practices. Thailand and the Philippines show moderate discard rates, while Cambodia, Malaysia, Singapore, and Timor-Leste have the lowest. Factors include gear type, regulatory strictness, infrastructure, and awareness levels.

To address discards, countries should promote selective gear, incentivize bycatch utilization, and mandate reporting. Regional data centers could help monitor and minimize discards.

Finally, threats to marine biodiversity embodied in imports reveal that Singapore has the largest ecological footprint, followed by Malaysia, Thailand, and Brunei. Their dependence on imported seafood and commodities affects ecosystems in supplier countries. Indonesia and the Philippines also contribute, though to a lesser extent. Reducing marine biodiversity threats requires sustainable import standards, diversified sourcing, and shared accountability within global supply chains.

Policy Efforts in Southeast Asia Countries: Overexploited Stocks in ASEAN Waters

Overexploitation of fish stocks in Southeast Asian waters poses a critical threat to marine biodiversity, coastal livelihoods, and regional food security. The Exclusive Economic Zones (EEZs) of ASEAN countries have experienced significant depletion, with up to 60% of fish catches in some areas coming from overfished stocks, particularly in Thailand. In response, Southeast Asian countries have initiated various policy frameworks to promote sustainable fisheries, although progress remains uneven due to disparities in institutional capacity, economic priorities, and governance structures.

One of the key policy instruments is the Voluntary National Reviews (VNRs) submitted to the United Nations. Thailand, for instance, completed VNRs in 2017 and 2021 to demonstrate its commitment to the Sustainable Development Goals (SDGs). The 2021 VNR integrates the SDGs into the 13th National Development Plan (2023–2027), highlighting environmental and marine sustainability. However, compared to peers like Indonesia and the Philippines, Thailand's VNRs lack transparency and wider civil society engagement. Furthermore, Thailand omits discussions on international spillovers such as fisheries exports and transboundary environmental impacts a notable shortcoming given regional interdependencies.

The integration of SDGs into national budgets has also seen mixed results. Thailand explicitly allocates funds toward SDG-related sectors such as health and renewable energy, with a 15% budget increase for green projects by 2023. However, fisheries and forestry remain underfunded, limiting the implementation of sustainability-focused reforms in these sectors. Contrastingly, countries like Indonesia have made progress by aligning maritime sustainability with broader development initiatives like the Maritime Toll Program.

In the area of monitoring and data, Thailand has established 172 national indicators aligned with 85% of global SDG targets. The National Statistics Office (NSO) oversees this process, yet real-time data on overfishing, bycatch, and Illegal, Unreported, and Unregulated (IUU) fishing remain insufficient. This is a regional challenge, particularly in Least Developed Countries (LDCs) such as Myanmar and Cambodia, where manual data collection hinders effective monitoring. In response, some nations like Indonesia have begun to deploy satellite and AI technologies for real-time fisheries surveillance, especially in sensitive areas like the Natuna Sea.

Efforts to develop sector-specific strategies are evident across ASEAN. Thailand has included plastic waste reduction targets and established an SDGs Coordination Center to streamline policy implementation. Nevertheless, inter-ministerial coordination remains weak, with overlapping responsibilities between environmental and energy ministries. Meanwhile, Indonesia, the Philippines, and Singapore have pioneered more integrated strategies. The Philippines' Ecotourism Development Act transformed coral reefs into profitable tourism assets, contributing significantly to marine GDP. Singapore's bioremediation technology reduced chemical water pollution by 40% in just five years.

Despite these developments, destructive fishing practices persist. Bottom trawling continues in Thailand and Vietnam, accounting for 35% of fishing activity and destroying seabed habitats. The use of trawl nets in Myanmar and Cambodia results in bycatch levels as high as 40%. Small-scale fishers often cannot afford selective gear like Turtle Excluder Devices, and policy incentives for sustainable fishing such as ecolabel certification remain limited. Thailand is beginning to address this issue by shifting 30% of its fishing fuel subsidies toward environmentally friendly technologies, which has already reduced bycatch by 25%.

Regional cooperation is increasingly recognized as essential. The ASEAN Regional Plan of Action on Sustainable Fishing (2023) aims to harmonize policies and combat IUU fishing across shared waters. However, implementation challenges persist due to differences in enforcement capacity and economic priorities. For example, Laos and Cambodia allocate less than 1% of their national budgets to marine conservation, underscoring the need for financial and technological support from ASEAN bodies and international partners such as the World Bank.

Ecological footprint issues add further complexity. The demand for shrimp exports in Singapore and Malaysia has led to the destruction of over 500,000 hectares of mangroves in Vietnam and Indonesia between 2020 and 2023. This illustrates how import patterns and unsustainable aquaculture practices exacerbate environmental degradation. Singapore's introduction of a carbon tax on marine imports represents a promising step toward addressing such externalities, and may serve as a model for other ASEAN states.

To ensure long-term sustainability, policy innovation and coordination are crucial. Recommendations for improvement include building LDC capacity through targeted aid, expanding marine protected areas (MPAs), and subsidizing transitions to sustainable gear. For example, community-based monitoring in Timor-Leste under the ATSEA-2 project, though limited in scale, shows how grassroots initiatives can contribute to conservation. Moreover, Vietnam's adoption of Marine Spatial Planning (MSP) in Ha Long Bay provides a best-practice model for balancing tourism, conservation, and fisheries.

In conclusion, while policy efforts in Southeast Asia demonstrate a growing awareness of the urgent need for sustainable fisheries, much remains to be done. A holistic approach combining regional harmonization, inclusive governance, technological innovation, and equitable financial support is essential to reverse the trend of overexploitation and secure a sustainable marine future for ASEAN waters.

DISCUSSION

The findings on marine Key Biodiversity Areas (KBAs) in Southeast Asia show a wide range in how different countries protect their marine environments. These differences can be explained by variations in government policies, financial and human resources, and

national priorities. For example, countries like the Philippines, Indonesia, and Malaysia show high protection rates (60–100%), while Thailand, Vietnam, and Brunei offer moderate protection (20–50%), and Cambodia, Myanmar, Timor-Leste, and Singapore provide low protection (<20%). This supports Lee et al. (2020), who highlight that effective marine conservation needs strong governance and local community participation.

Countries with higher protection, such as the Philippines and Indonesia, benefit from robust legal frameworks and grassroots involvement. The Philippines uses a decentralized system called the National Integrated Protected Areas System (NIPAS), while Indonesia manages one of the world's largest marine reserve networks. These community-based approaches help improve the long-term success of marine protected areas (MPAs) (Satizábal et al., 2020; Okafor-Yarwood et al., 2020). However, enforcement challenges still exist. Illegal, Unreported, and Unregulated (IUU) fishing continues in the Philippines, and remote Indonesian waters like the Arafura Sea face monitoring problems (Ntona & Morgera, 2018).

Moderate protection countries like Thailand and Vietnam face other challenges. Thailand's tourism-heavy coasts (e.g., Phuket and Krabi) strain marine ecosystems, reflecting Harris et al. (2018) who noted how tourism and conservation often conflict. Vietnam deals with high levels of pollution, especially in the Mekong Delta, which undermines marine protection. Brunei, while less polluted, lacks the capacity for large-scale conservation. This fits Sachs et al. (2024), who emphasize that Sustainable Development Goal (SDG) 14 success depends heavily on national capacity only 6 out of 11 Southeast Asian countries have met the 17% protection goal.

In contrast, low-protection countries face systemic problems. Cambodia protects only 1.7% of its marine area, and Myanmar has almost no meaningful marine conservation. These gaps stem from poor governance and very limited funding. Timor-Leste has made some progress through international support programs like ATSEA-2, while Singapore's heavy industrialization leaves little space for marine protection. According to Martínez-Vázquez et al. (2021), aligning national policies with SDG 14 and increasing funding could help countries like Cambodia and Myanmar catch up.

Despite space limits, Singapore's use of technology for marine habitat restoration such as marine biorefineries is a positive example of innovation in small urbanized countries (Verissimo et al., 2021). The Ocean Health Index (OHI) also shows the contrast across the region: Singapore scores around 80 due to strong environmental laws, while Myanmar scores just 30, mostly due to ongoing conflict and poor infrastructure (Haas, 2023). Indonesia (55), the Philippines (40), and Vietnam (35) face serious issues from plastic and industrial pollution (Sridharan et al., 2021). The complexity of managing archipelagos and lack of public awareness further complicate conservation efforts (Mao et al., 2019).

To bridge these gaps, ASEAN's Framework of Action on Marine Debris (2021) promotes regional collaboration, while Thompson (2025) calls for better waste treatment systems. Regional teamwork could be the key to solving transboundary issues like plastic pollution and fish stock depletion.

Overfishing is also a critical concern. Cambodia and Vietnam suffer from overexploited fish stocks and unsustainable trawling. Thailand and Malaysia also face high exploitation, while Vietnam's pressures are market-driven (Lee et al., 2020). Destructive fishing gear such as bottom trawls is still widely used in Thailand (35%) and Myanmar (40% bycatch). Stephenson and Hobday (2024) suggest switching to eco-friendly fishing gear as a sustainable solution. Brunei and Singapore, with stricter rules and less reliance on fishing, offer useful models.

In addition, Vietnam has the highest levels of bycatch and discards, showing weak fishing practices. Meanwhile, Singapore, which imports most of its seafood, reduces its local marine impact an approach linked to better ecosystem service management by Peña et al. (2022).

On the policy side, Thailand's Voluntary National Reviews (VNRs) show progress, but still lack coordination across sectors. In contrast, Indonesia has integrated SDGs into

its maritime policies more effectively (Sarangi, 2023). Myanmar and Cambodia continue to struggle with minimal funding for marine efforts less than 1% of the national budget but this could be improved through international aid (Nabi & Hayat, 2025). Singapore's carbon tax on imports and the Philippines' ecotourism model, which contributes 5% to GDP, show that economic tools can support marine goals (Baker et al., 2023; Islam et al., 2024).

Regional initiatives like the ASEAN 2023 Action Plan on Sustainable Fishing, along with community-based monitoring in Timor-Leste (ATSEA-2), offer hope for collective improvement. These initiatives are in line with the concept of "strong sustainability" discussed by Neumann et al. (2017), which stresses lasting environmental, economic, and social harmony.

This shows that marine biodiversity protection in Southeast Asia is uneven and depends on governance quality, resource capacity, and public participation. Countries like the Philippines and Indonesia demonstrate that local involvement and blue economy integration can work well. On the other hand, nations with weak institutions or limited funding lag behind. Regional cooperation, innovation, and financial support especially under SDG 14 are essential for long-term marine sustainability. To succeed, Southeast Asia must strengthen shared frameworks, adopt smarter technologies, and ensure inclusive governance to protect its rich marine ecosystems.

CONCLUSION

The sustainability of marine ecosystems in Southeast Asia remains a pressing challenge due to disparities in institutional capacity, policy implementation, and resource allocation among countries. While nations like Indonesia, Malaysia, and Singapore demonstrate notable progress in protecting marine Key Biodiversity Areas (KBAs) and managing waste through national and regional initiatives, least developed countries (LDCs) such as Laos, Cambodia, and Myanmar continue to face significant constraints. These include limited budgets, inadequate technology, and conflicting land-based development priorities.

Marine environmental degradation in the region is further exacerbated by overexploitation of fish stocks, destructive fishing practices like bottom trawling, and widespread bycatch, particularly in Myanmar and Cambodia. Despite regulatory frameworks, poor policy enforcement and the unaffordability of selective fishing technology hinder conservation efforts. Additionally, the region's increasing demand for marine products, especially shrimp, has driven large-scale mangrove destruction, particularly in Vietnam and Indonesia, contributing to biodiversity loss and heightened ecological vulnerability.

However, innovative national responses to these issues have emerged. Indonesia's integration of maritime logistics with marine conservation, the Philippines' coral reef ecotourism initiatives, and Singapore's implementation of carbon taxes and bioremediation technologies offer promising models. Nevertheless, these remain insufficient unless accompanied by coordinated regional action and support for weaker states.

To achieve sustainable marine management, strategic efforts must focus on enhancing LDC capacity, harmonizing regional marine policies, incentivizing transitions to environmentally friendly fishing gear, and improving real-time marine data systems. Importantly, regulating ecological footprints through environmental taxes and adopting Marine Spatial Planning (MSP) can mitigate habitat degradation. Redirecting subsidies toward sustainable practices and strengthening transnational cooperation such as ASEAN's Regional Plan of Action on Sustainable Fishing will be crucial for addressing illegal, unreported, and unregulated (IUU) fishing and promoting long-term resilience. Overall, implementing an inclusive and integrated blue economy across Southeast Asia demands shared commitment, equitable resource distribution, and policy coherence to safeguard marine ecosystems for future generations.

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