Sustainable Marine Fisheries Management as an Effort to Maintain Fish Resource Resilience

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Abstract

Sustainable marine fisheries management has become a critical global issue due to the increasing pressure on fish resources caused by overfishing, environmental degradation, and climate change. Indonesia, as one of the world's largest maritime nations, faces significant challenges in maintaining fish stock resilience while ensuring food security and livelihoods for coastal communities. This study aims to analyze sustainable marine fisheries management practices as an effort to maintain fish resource resilience by integrating ecological, economic, and social dimensions. The research employed a descriptive-analytical approach based on secondary data obtained from national fisheries statistics, scientific journals, and international reports published between 2015 and 2025. Data were analyzed using a qualitative synthesis method supported by sustainability indicators, including stock status, fishing effort, governance effectiveness, and community participation. The results indicate that sustainable fisheries management, particularly ecosystem-based fisheries management, rights-based fisheries, and the implementation of blue economy principles, significantly contributes to maintaining fish stock resilience. However, governance gaps, weak enforcement, and limited stakeholder integration remain major constraints. This study concludes that strengthening institutional capacity, improving data quality, and enhancing community-based management are essential to achieving long-term sustainability of marine fisheries resources. The findings provide practical and theoretical contributions to fisheries management policy development in Indonesia and other developing maritime countries.

Introduction

Marine fisheries play a pivotal role in global food security, economic development, and the livelihoods of millions of coastal communities across the world. Fish resources serve as a primary source of high-quality animal protein, essential micronutrients, and fatty acids, particularly for populations in coastal and island nations where alternative protein sources may be limited (FAO, 2020). Beyond their nutritional importance, marine fisheries generate substantial employment opportunities along the entire value chain, including harvesting, processing, marketing, and distribution, thereby contributing

significantly to poverty alleviation and regional economic development. This role is especially pronounced in developing maritime countries such as Indonesia, where fisheries form a socio-economic backbone for coastal communities. However, despite their importance, marine fisheries are increasingly threatened by escalating fishing pressure, rapid technological advancements that intensify harvesting capacity, and weak governance structures that fail to regulate exploitation effectively. These factors have led to declining fish stocks, habitat degradation, and disruptions to marine ecosystems in many parts of the world, raising serious concerns about the long-term sustainability of marine fisheries resources (Hilborn, 2018).

In the Indonesian context, marine fisheries contribute substantially to national food supply, export revenues, and economic growth, positioning the sector as a strategic component of national development. Indonesia's vast marine area and high biodiversity provide enormous potential for fisheries-based development; however, this potential is increasingly undermined by unsustainable exploitation practices. Several studies have reported that a significant proportion of Indonesian fish stocks are currently fully exploited or overexploited, indicating that fishing activities in many fisheries management areas have reached or exceeded sustainable limits (Putra et al., 2023; Arief et al., 2025). Such conditions pose serious risks to long-term fish stock resilience, ecosystem stability, and the livelihoods of coastal communities that depend on marine resources. These challenges underscore the urgent need for effective and sustainable fisheries management strategies that are capable of balancing resource utilization with conservation objectives. Without timely and comprehensive management interventions, continued overexploitation may lead to stock collapse, reduced economic returns, and increased vulnerability of coastal populations. Consequently, strengthening sustainable marine fisheries management has become a critical priority to ensure ecological integrity, economic viability, and social resilience in Indonesia's marine fisheries sector.

Sustainable marine fisheries management emphasizes the integrated consideration of ecological, economic, and social dimensions as a unified framework for achieving long-term resource resilience. This integrated perspective recognizes that fisheries systems are complex socio-ecological systems in which biological processes, human behavior, and institutional arrangements are closely interconnected. Ecosystem-Based Fisheries Management (EBFM) has therefore been widely promoted as a holistic approach that moves beyond single-species management by explicitly accounting for interactions among fish stocks, habitats, trophic relationships, and human activities such as fishing, coastal development, and pollution (Rusandi et al., 2021). By incorporating ecosystem dynamics and cumulative impacts, EBFM seeks to maintain ecosystem structure, function, and productivity while still allowing sustainable levels of resource utilization. Empirical evidence suggests that fisheries managed under EBFM frameworks tend to be more resilient to environmental variability and external shocks, including climate change, compared to fisheries governed by conventional management approaches. Consequently, EBFM is increasingly regarded as a cornerstone of sustainable marine fisheries management, particularly in biodiversity-rich and multi-species fisheries such as those found in Indonesian waters.

In addition to ecological considerations, governance mechanisms play a decisive role in determining the effectiveness of sustainable fisheries management. Previous studies highlight that governance instruments such as rights-based fisheries, co-management arrangements, and active community participation can significantly improve compliance with regulations and reduce the incidence of overfishing (Gopabala Krishnan & Sin, 2024). By clearly defining access rights and management responsibilities, these approaches create incentives for fishers to engage in responsible harvesting practices and support conservation measures. In the Indonesian context, the implementation of fisheries management areas and marine conservation zones has demonstrated positive impacts on fish stock recovery, habitat protection, and ecosystem resilience (Iman et al., 2025). However, despite these achievements, implementation challenges persist, including limited institutional capacity, inconsistent enforcement, and varying levels of stakeholder engagement across regions. These constraints indicate that while governance innovations have strong potential to enhance sustainability, their success depends on

effective coordination among institutions, adequate resources, and inclusive participation of all relevant stakeholders. Strengthening governance frameworks is therefore essential to translate sustainable fisheries management principles into tangible improvements in fish resource resilience (Rumolo, 2023).

Another emerging concept in sustainable fisheries is the blue economy, which promotes economic growth while preserving marine ecosystems. The integration of blue economy principles into fisheries management has been found to enhance value chains, reduce environmental impacts, and support fish stock resilience (Kaunang et al., 2025). Despite extensive studies on fisheries sustainability, gaps remain in understanding how integrated management approaches effectively contribute to fish resource resilience in developing countries. Many policies still focus on production targets rather than long-term ecosystem health (Hehanussa, 2023).

Therefore, this study aims to analyze sustainable marine fisheries management as an effort to maintain fish resource resilience by synthesizing recent scientific evidence and policy practices. The study contributes to fisheries management literature by providing a comprehensive framework that integrates ecological sustainability, governance, and socio-economic considerations relevant to Indonesia's marine fisheries sector.

Methods

This study employed a descriptive-analytical research design using secondary data. Data were collected from peer-reviewed journals, national fisheries reports, and international publications issued between 2015 and 2025. Sources included scientific databases, government publications, and reports from international organizations such as FAO and UNEP. The analysis focused on sustainability indicators, including fish stock status, fishing effort, management instruments, governance effectiveness, and stakeholder involvement. A qualitative synthesis approach was applied to compare findings across studies and identify patterns related to sustainable fisheries management and fish stock resilience.

Results and Discussion

The findings of this study demonstrate that sustainable marine fisheries management plays a significant and multidimensional role in maintaining fish resource resilience, particularly when ecological principles are positioned at the core of management strategies. Fisheries that adopt ecosystem-based fisheries management (EBFM) consistently exhibit greater stability in fish stock dynamics and improved overall ecosystem health compared to conventional single-species management approaches. This is largely because EBFM acknowledges fisheries as part of complex socio-ecological systems, where target species, non-target species, habitats, and environmental drivers interact in dynamic and often non-linear ways. By explicitly considering these interactions, EBFM enables managers to address cumulative impacts of fishing activities, habitat alteration, and environmental variability, which are frequently overlooked in traditional management frameworks.

According to Hilborn (2018), fisheries management systems that integrate ecological thresholds, precautionary reference points, and habitat protection measures are more effective in preventing stock depletion and minimizing the risk of sudden stock collapse. Such systems allow managers to respond proactively to early warning signals of ecosystem stress rather than relying solely on retrospective stock assessments. Furthermore, EBFM supports the maintenance of essential fish habitats, such as spawning and nursery grounds, which are critical for recruitment success and long-term population resilience. Protecting these habitats not only benefits target species but also preserves biodiversity and ecosystem functions that underpin fisheries productivity.

Empirical evidence from Indonesia further reinforces the effectiveness of ecological-based management approaches. Rusandi et al. (2021) reported that the implementation of marine protected

areas and ecosystem-based zoning contributed to significant increases in fish biomass, improved size structure of fish populations, and reduced exploitation pressure on vulnerable and slow-growing species. These outcomes suggest that spatial management tools, when embedded within an ecosystem-based framework, can serve as effective mechanisms for rebuilding depleted stocks and enhancing ecosystem resilience. Moreover, such measures provide ecological buffers that increase the capacity of marine ecosystems to absorb external disturbances, including climate-induced changes such as ocean warming and shifting species distributions.

Overall, these findings indicate that ecological-based fisheries management not only supports biological sustainability in terms of stock recovery and biodiversity conservation but also strengthens the adaptive capacity of marine ecosystems in the face of escalating anthropogenic pressures and climate variability. By maintaining ecosystem structure, function, and productivity, EBFM creates the ecological foundation necessary for sustainable fisheries and long-term food security. Consequently, placing ecological principles at the center of fisheries management should be regarded not as an optional strategy but as a fundamental requirement for ensuring the resilience and sustainability of marine fish resources.

In addition to ecological considerations, governance mechanisms are a decisive factor influencing the success of sustainable fisheries management. Effective governance frameworks, such as rights-based fisheries management and clearly defined fisheries management areas, have been shown to improve compliance among fishers and reduce illegal, unreported, and unregulated (IUU) fishing activities. Putra et al. (2023) emphasized that assigning clear access rights and management responsibilities encourages fishers to adopt more responsible fishing practices, as they perceive long-term benefits from resource conservation. However, despite these positive outcomes, governance challenges remain prominent in Indonesia's marine fisheries sector. Arief et al. (2025) highlighted that weak law enforcement, overlapping institutional mandates, and limited inter-agency coordination often undermine policy implementation at the local level. Furthermore, inadequate monitoring and data limitations constrain the ability of managers to enforce regulations effectively. These governance gaps suggest that sustainable fisheries management requires not only sound policies but also strong institutional capacity, transparent decision-making processes, and active collaboration among government agencies, local communities, and other stakeholders to ensure the resilience of fish resources over the long term.

Community-based fisheries management (CBFM) has increasingly emerged as an effective and context-sensitive approach to enhancing sustainability, particularly within small-scale and artisanal fisheries that dominate many coastal regions in Indonesia. This management paradigm emphasizes the active and meaningful involvement of local fishers and coastal communities in decision-making processes, resource monitoring, and rule enforcement. Unlike top-down management approaches, CBFM recognizes local communities as key actors rather than passive beneficiaries, thereby fostering a sense of ownership and shared responsibility over marine resources. When communities are directly involved in defining fishing rules, seasonal closures, gear restrictions, and spatial management measures, compliance tends to increase as regulations are perceived as legitimate and aligned with local needs and realities.

By granting communities greater authority and responsibility, CBFM strengthens stewardship and encourages fishers to adopt more sustainable harvesting practices. Laitupa et al. (2023) demonstrated that fisheries adopting community-based approaches exhibited higher levels of compliance with fishing restrictions, improved livelihood sustainability, and greater resilience of target species compared to fisheries managed solely through centralized regulatory frameworks. These outcomes are particularly important in small-scale fisheries, where enforcement capacity is often limited and social norms play a critical role in shaping behavior. Community-based monitoring and peer enforcement mechanisms can therefore complement formal regulatory systems, reducing management costs while enhancing effectiveness.

Moreover, local ecological knowledge possessed by fishers constitutes a valuable asset in community-based management systems. Fishers often have detailed and place-specific knowledge regarding seasonal migration patterns, spawning periods, critical habitats, and environmental changes, derived from long-term interaction with marine ecosystems. Integrating this local knowledge with scientific data can improve the accuracy and relevance of management decisions, especially in data-poor fisheries where conventional stock assessments are difficult to conduct. Such knowledge integration enhances adaptive capacity by allowing management measures to respond more rapidly to ecological changes and emerging threats (Laksmana et al., 2024).

Beyond ecological benefits, CBFM also contributes to broader social and institutional outcomes. Participatory governance strengthens social cohesion, trust, and collective action within fishing communities, which are essential elements for long-term sustainability. By empowering communities and recognizing their role in resource governance, CBFM supports social equity and reduces conflicts over resource use. These findings suggest that community-based fisheries management not only plays a significant role in maintaining fish stock resilience and long-term ecological sustainability but also serves as a foundation for socially inclusive and resilient fisheries governance systems in Indonesia and other developing maritime nations.

In addition to community-based approaches, the integration of blue economy principles has further strengthened sustainable marine fisheries management by promoting economic growth that is aligned with environmental conservation. The blue economy framework encourages value-added fisheries activities, efficient resource utilization, and environmentally responsible practices throughout the fisheries value chain. According to Kaunang et al. (2025), the adoption of blue economy principles enables fisheries to shift from volume-oriented exploitation toward quality-based production, thereby reducing pressure on fish stocks while increasing economic returns for fishers. This approach also supports the development of eco-friendly technologies, sustainable aquaculture, and post-harvest processing innovations that minimize waste and environmental impacts. Furthermore, by aligning economic incentives with conservation objectives, the blue economy framework creates a mutually reinforcing relationship between ecosystem health and economic viability. Consequently, integrating blue economy strategies into fisheries management policies can serve as a powerful tool to enhance fish resource resilience, promote inclusive economic development, and ensure the long-term sustainability of marine fisheries in Indonesia and other developing maritime nations.

Despite the positive contributions of ecosystem-based management, community participation, and blue economy integration, several structural and operational constraints continue to hinder the effective implementation of sustainable marine fisheries management. One of the most critical challenges is the limited quality and availability of fisheries data, particularly in small-scale fisheries where catch reporting, effort monitoring, and stock assessments remain weak. Inadequate data compromise the accuracy of management decisions and limit the ability of fisheries managers to apply precautionary and adaptive management approaches (FAO, 2022). Moreover, insufficient monitoring, control, and surveillance (MCS) systems reduce the effectiveness of regulations and allow illegal, unreported, and unregulated fishing to persist, thereby threatening fish stock resilience. Socio-economic pressures also play a significant role, as many fishers depend heavily on daily catches for their livelihoods, making short-term economic needs often outweigh long-term conservation considerations. These conditions are further exacerbated by climate change impacts, such as shifting fish distribution, ocean warming, and habitat degradation, which increase uncertainty and complexity in fisheries management. Therefore, addressing these challenges requires a holistic and adaptive management framework that strengthens data collection systems, enhances institutional capacity, integrates climate change considerations, and provides alternative livelihood options for coastal communities. Such an approach is essential to ensure that sustainable

fisheries management not only preserves ecological integrity but also supports social equity and economic resilience in the long term.

Conclusion

This study concludes that sustainable marine fisheries management plays a fundamental and strategic role in maintaining fish resource resilience amid increasing ecological and socio-economic pressures. The findings demonstrate that management approaches integrating ecosystem-based fisheries management, community participation, and blue economy principles are particularly effective in supporting the long-term sustainability of marine fisheries. Ecosystem-based management ensures that ecological processes and habitat integrity are preserved, while community-based approaches enhance compliance, stewardship, and social legitimacy. Meanwhile, the integration of blue economy principles aligns conservation objectives with economic incentives, enabling fisheries to achieve sustainability without compromising the livelihoods of coastal communities.

However, the effectiveness of these approaches is highly dependent on the presence of strong governance systems, reliable and high-quality fisheries data, and robust institutional capacity. Weak law enforcement, fragmented institutional coordination, and limited monitoring and data collection remain significant barriers to achieving optimal management outcomes. These challenges are further compounded by socio-economic dependence on marine resources and the growing impacts of climate change, which introduce additional uncertainty into fisheries systems. Therefore, sustainable marine fisheries management must be supported by adaptive governance frameworks that emphasize evidence-based decision-making, cross-sectoral collaboration, and continuous learning.

The findings of this study provide important theoretical and practical implications for policymakers, fisheries managers, and stakeholders, particularly in developing maritime countries. By highlighting the need for integrated, adaptive, and participatory management strategies, this research contributes to the broader discourse on fisheries sustainability and resource resilience. Future research is recommended to focus on empirical and location-specific assessments of management effectiveness, the incorporation of climate change adaptation measures, and the evaluation of socio-economic trade-offs to further strengthen sustainable marine fisheries management frameworks.

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