

EAFM of grouper in the Spermonde Islands, South Sulawesi, located in the UGGp Maros-Pangkep area

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Abstract. The Spermonde Islands, part of the Maros-Pangkep UNESCO Global Geopark, depend heavily on small-scale multi-gear demersal fisheries. This study assessed the sustainability of grouper fisheries using the Ecosystem Approach to Fisheries Management (EAFM) indicators across six domains (Fisheries Resources, Habitat and Ecosystems, Fishing Technology, Social, Economic, and Governance). Data were collected from ten target islands between October 2023 and January 2024. The results yielded an aggregate EAFM score of 61 (Good classification). However, a domain-level analysis revealed critical ecological vulnerabilities, with 'Fishery Resources' (score 48) and 'Fishing Technology' (score 50) falling into the Moderate category. While the fishery is economically profitable, it faces threats from overfishing, juvenile exploitation, and destructive fishing practices. Consequently, management interventions must prioritize strengthening law enforcement, protecting spawning aggregation sites, and enhancing stakeholder participation to ensure long-term sustainability. These findings provide a scientific basis for the improvement of the WPP 713 management plan.

Keywords: Ecosystem Approach to Fisheries Management (EAFM), Spermonde Islands, sustainable fisheries, demersal fisheries, grouper

1 Introduction

As the world's largest archipelagic country, Indonesia has vast potential for maritime economic development, and capture fisheries constitute a major contributor to this sector [1]. As one of the leading global producers of fisheries, the country faces multifaceted challenges

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in ensuring sustainable management of its resources [2]. To address these challenges, Indonesia has adopted the Ecosystem Approach to Fisheries Management (EAFM) as a fundamental principle in the Fisheries Management Plan (RPP) at the Fisheries Management Area (WPP) level. According to the NWG EAFM module (2014), the EAFM framework in Indonesia is structured around six key domains of assessment: Fishery Resources, Habitats and Ecosystems, Fishing Technology, Social, Economic, and Institutional/ Governance.

The Spermonde Archipelago, located within the Coral Triangle and Wallacea biodiversity hotspot, is one of the six major island groups surrounding Sulawesi. It lies between the southern arc of Sulawesi in Central Indonesia and the Strait of Makassar [4]. A part of this area has been designated as the Maros-Pangkep UNESCO Global Geopark, which also encompasses marine conservation zones. The local communities in these islands are highly dependent on small-scale fisheries that target multiple fish species (multi-species) using various fishing gear (multi-gear) [5]. However, there is strong evidence that coral reef ecosystems and fishery resources in the region are under severe pressure owing to overfishing, destructive fishing practices, and environmental degradation caused by pollution and sedimentation [2].

Among existing fishery commodities, groupers (family Serranidae) are both economically and ecologically important. Their life history traits, such as protogynous hermaphroditism (sex change from female to male), late sexual maturity, and tendency to form spawning aggregations (SPAGs), make them highly vulnerable to overfishing [6]. Given the importance of this commodity and the threats it faces, comprehensive evaluation is essential. Despite their high value, scientific assessments of grouper fisheries sustainability under the Ecosystem Approach to Fisheries Management (EAFM) framework remain limited, particularly within the Maros–Pangkep Geopark area. To address this knowledge gap, this study aims to (a) assess the status of grouper fisheries in the Maros-Pangkep Geopark using EAFM indicators, (b) identify key issues requiring intervention, and (c) provide science-based management recommendations for the sustainability of grouper fisheries in the region.

2 Methodology

This study was conducted from October 2023 to January 2024 in the Spermonde Archipelago, which is located within the districts of Liukang Tupabbiring and North Liukang Tupabbiring, Pangkep Regency, South Sulawesi, and falls under Indonesian Fisheries Management Area (FMA) 713 (**Fig. 1**). The assessment methodology followed the *Technical Guidelines for EAFM Indicator Assessment* issued by the Ministry of Marine Affairs and Fisheries (MMAF) through Regulation of the Director General of Capture Fisheries No. 18/KEP-DJPT/2014. The assessment covered 32 standard indicators, categorized into six EAFM domains.

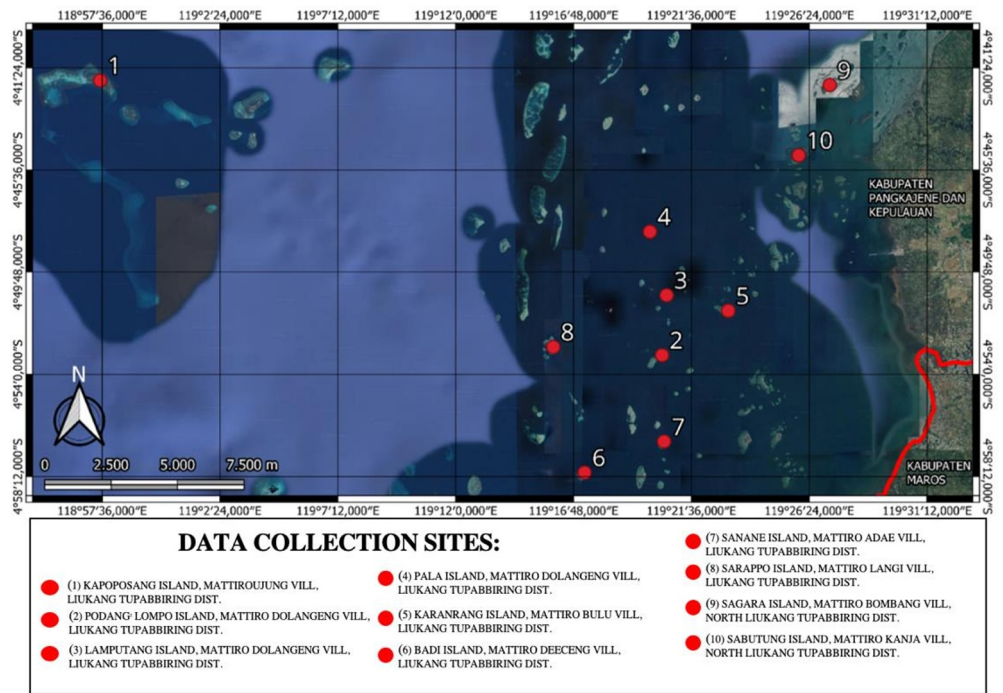


Fig. 1. Study area within the Maros-Pangkep Geopark, located in the Spermonde Archipelago, South Sulawesi, Indonesia.

Each indicator was assessed using criteria that generated scores on a three-point Likert scale (1 = Poor/Red, 2 = Moderate/Yellow, and 3 = Good/Green). These scores were then converted into composite values ranging from 1 to 100, and visualized using a five-level flag model (Table 1). The weighting of each indicator was adjusted based on expert consultation with specialists at the EAFM Learning Center, Hasanuddin University (LC-EAFM UNHAS) to ensure relevance to local fishery conditions.

The EAFM assessment was conducted by converting the collected data into a numerical Likert scale with three fundamental levels: score 1 (Very Poor/Red), 2 (Moderate/Yellow), and 3 (Very Good/Dark Green), which was subsequently expanded into a five-level color-coded scale to represent intermediate conditions, namely Poor (Orange) between Levels 1 and 2, and Good (Light Green) between Levels 2 and 3. Each indicator was assigned a weight according to its relative contribution to the EAFM principles, producing composite domain scores (ranging from 1 to 100) and an overall fishery score calculated using an embedded algorithm.

The evaluation results were visualized using a five-level color-coded Flag Diagram, which reflects the extent to which fisheries management aligns with the principles of EAFM. The Flag Diagram, also known as the Flag Model, is an analytical visual tool used to illustrate the performance of fisheries management across various domains such as ecological, social, and governance aspects.

Data were collected using two main approaches. Primary Data were obtained through field visits to ten islands, direct observations, and semi-structured key informant interviews. Respondents included a wide range of stakeholders, such as government officials, fishers, fish traders, academics, and representatives of non-governmental organizations. Secondary Data were derived from scientific literature reviews, fishery statistics from local governments, research reports, and other relevant documents from governmental and non-

governmental stakeholders. The preliminary assessment results were subsequently refined and validated through a Focus Group Discussion (FGD) involving key stakeholders in Makassar.

3 Results

3.1 Overview of grouper fisheries

Demersal fisheries in the Spermonde Archipelago, including grouper fisheries, are small-scale, multi-species, and multi-gear fisheries. At least 39 grouper species from various genera (*Epinephelus*, *Plectropomus*, *Cephalopholis*, etc.) were targeted by fishers in the study area. Among these, the leopard coral grouper (*Plectropomus leopardus*) is the most heavily exploited species and has been classified as over-exploited in the study area [7], although its global conservation status on the IUCN Red List is *Least Concern (LC)*. Based on field observations and interviews, the main centers of grouper fisheries are Badi Island and Sarappo Lompo Island. The predominant fishing gear used for catching groupers is a handline with artificial baits and traps.

3.2 EAFM assessment of grouper fisheries

The EAFM evaluation of grouper fisheries in the Spermonde Archipelago yielded an aggregate score of 61 out of 100, which fell into the ‘Good’ category. However, a more detailed analysis of each domain revealed the significant challenges underlying the aggregate score (Table 1, Fig. 2).

Table 1. Flag model of EAFM Assessment Scores for Grouper Fisheries in the Spermonde Archipelago

Domain	Composite Score	Category
Fishery Resources	48	Moderate
Habitat & Ecosystem	67	Good
Fishing Technology	50	Moderate
Social	53	Moderate
Economic	80	Good
Governance	67	Good
Aggregate	61	Good

Fishery Resources Domain (Score 48 – Moderate): This domain represents the most concerning condition. An FMA 713 stock assessment [8] indicated a relatively low proportion of juveniles among the most commonly caught species. However, secondary data from local studies show that around 33% of the observed catch was juveniles, with just under 60% classified as young fish approaching maturity, and the remaining adults. Many of these juveniles have not been recorded in official statistics because they are consumed locally or sold in local markets. This pattern is consistent with broader stock assessment results and field observations that indicate a declining trend in Catch Per Unit Effort (CPUE) and a downward trend in the average size of the captured fish. Fishers have also reported that target species have become more difficult to identify, suggesting the occurrence of a range collapse.

Habitat and Ecosystem Domain (Score 67 – Good): Although generally rated as good, this domain still faces several issues. Water quality was assessed as “slightly polluted” owing

to the impacts of land-based activities and settlements on the islands. Key ecosystems, such as coral reefs, seagrass beds, and mangroves, were rated as moderate, reflecting historical degradation and ongoing pressures. Moreover, there is no active management for known spawning aggregation sites (SPAGs), which are critical habitats for grouper reproduction. Despite these weaknesses, the aggregate score remains in the good category, suggesting that the habitat and ecosystem are still relatively intact, but face increasing risks of degradation if management actions are not strengthened.

Fishing Technology Domain (Score 50 – Moderate): This domain received a relatively low score owing to several factors. Destructive and illegal fishing practices remain a significant challenge in the Spermonde Archipelago, and are one of the main factors lowering the Fishing Technology Domain score. Field observations and discussions have revealed that explosives, poisons, and mini-trawls still occur frequently. These practices are carried out not only by fishers from outside the region but also within the study area. Although not directly targeting groupers, fishing capacity and effort have been assessed as excessive, leading to overexploitation. Furthermore, most fishers do not yet possess a fisher identification card (*KUSUKA*), which is essential for proper data collection and access to government programs.

Social Domain (Score 53 – Moderate): Active participation of stakeholders in fisheries management processes remains very limited, with most decision-making currently occurring without broad-based community engagement. Although open conflicts are rare, there is the potential for disputes related to access to fishery resources. The lack of participation and potential for conflict indicate the need to strengthen participatory mechanisms and dialogue among stakeholders to ensure more inclusive and sustainable fisheries management in the Spermonde Archipelago.

Economic Domain (Score 80 – Good): From an economic perspective, grouper fisheries remain highly profitable. Most grouper fishers earn income above the regional minimum wage and report an increase in asset ownership. However, household savings among fishermen remain very low, highlighting the financial vulnerability to fluctuations in catch and market prices.

Institutional/Governance Domain (Score 67 – Good): A Fisheries Management Plan for FMA 713 has been established, yet its implementation at the local level remains in the preparatory stage. Compliance with existing regulations is still low, and coordination among government institutions responsible for fishery management has not been fully effective. Field observations and focus group discussions (FGD) revealed limited synergy both within and among institutions across the horizontal and vertical levels. Although gaps and overlaps exist in policies, they are generally not in direct conflict with each other. These findings highlight the significant potential for enhanced stakeholder collaboration, particularly through targeted human resource development within communities and government agencies, which is critical for strengthening governance and achieving more effective and sustainable fishery management.

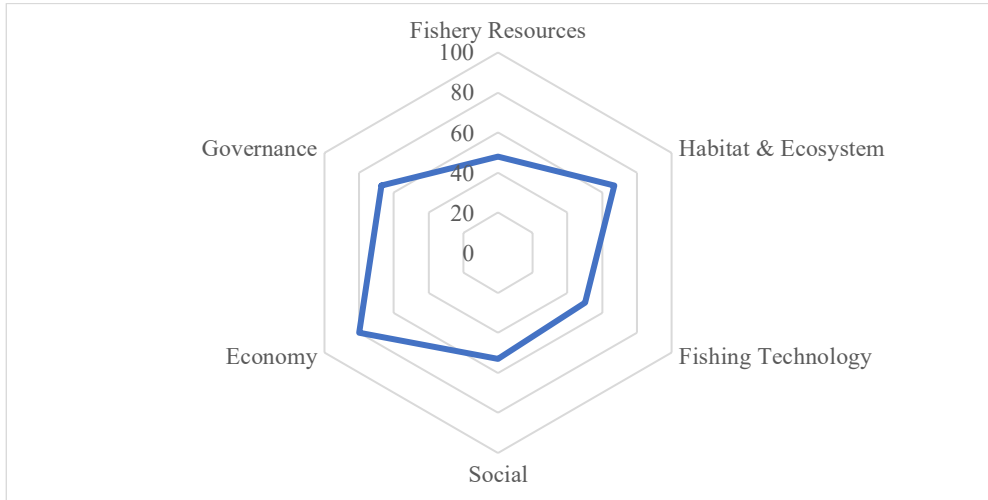


Fig. 2. Spider diagram illustrating the EAFM assessment scores for grouper fisheries in the Spermonde Archipelago across six domains. Higher scores extending farther from the center indicate better conditions.

The Spider Diagram derived from the EAFM assessment (**Fig. 2**) serves as a visual tool to reveal imbalances across the six domains of fishery management. Domain scores, ranging from Fishery Resources to Governance, were plotted on separate axes, forming an irregular shape that reflected the specific conditions of the evaluated fishery. The diagram indicates that while the economic domain scored relatively high (80 – good), domains such as Fishery Resources (48 – moderate) and Fishing Technology (50 – moderate) scored considerably lower, suggesting that ecological and technical sustainability have been compromised by short-term economic priorities.

Although the aggregate fishery score is categorized as good, several domains within this range (e.g., Habitat and Governance) lie close to the moderate threshold. Combined with declining trends in individual indicators, such as a decrease in CPUE within the Fishery Resources domain, this suggests a heightened risk of further degradation. Overall, the Spider Diagram highlights structural imbalances that require urgent attention to ensure the long-term socioeconomic and ecological sustainability of the grouper fishery in the Spermonde Archipelago.

4 Discussion

The EAFM assessment of grouper fisheries in the Spermonde Archipelago revealed a paradox commonly observed in many small-scale fisheries: an aggregate score classified as “Good,” largely driven by strong economic performance, yet masking ecological fragility and governance weaknesses. The “Moderate” scores in the Fishery Resources and Fishing Technology domains serve as clear warning signals that the biological foundation of these fisheries is being eroded. In particular, *Plectropomus leopardus*, one of the most targeted grouper species in the Spermonde Archipelago, has already reached an over-exploited status, and habitat degradation is a primary threat [7].

The low score in the Fishery Resources domain, reflected in declining CPUE, reduced fish size, and high proportion of juvenile catches, is a direct consequence of excessive fishing effort and capacity (overcapacity) identified in the Fishing Technology domain. Adopting sustainable fishing technologies is essential for controlling pressure on fishery resources.

From an ecological perspective, harvesting fish below maturity disrupts population dynamics and undermines the balance of food chains in the aquatic ecosystem [9]. However, these ecological risks are compounded by the persistence of illegal and destructive fishing practices that damage critical habitats such as coral reefs and indirectly diminish the productivity of grouper fisheries [10].

Meanwhile, the “Good” score in the economic domain must be interpreted with caution. Current income levels may not be sustainable if fish stock continues to decline. The economic vulnerability of fishers is also evident in the very low levels of savings, which limits their ability to adapt to a drastic decrease in the future. This aligns with EAFM economic indicators, which highlight household income, savings ratio, and asset ownership as key measures of resilience. If more than 75% of a household’s income is derived from the fisheries sector, the household is categorized as highly dependent on fishery resources [11]. This high level of dependency is also evident in the grouper fisheries of the Spermonde Archipelago, where most RTP come directly from fishing activities.

Weaknesses in Social and Institutional domains, such as limited stakeholder participation and weak law enforcement, constitute major barriers to the implementation of effective management measures. Without improvements in governance and rule enforcement, the status of fishery resources will continue to deteriorate, eventually undermining current economic performance [11]. This pattern is consistent with findings from other regions, where the transfer of authority under Law No. 23/2014 reduced opportunities for local stakeholder engagement, thereby weakening the effectiveness of fishery governance [12]. Similar challenges are evident in the Spermonde Archipelago, with low levels of fisher participation in decision-making and limited institutional coordination at both the vertical and horizontal levels.

5 Conclusion

This EAFM assessment concludes that although grouper fisheries in the Spermonde Archipelago remain economically profitable at present, their sustainability is highly threatened by intense exploitation pressure and weaknesses in the management system. The “Moderate” scores in the Fishery Resources and Fishing Technology domains represent critical indicators that demand urgent intervention. The overall EAFM score (61/100, good) indicates that the fishery operates under moderate sustainability conditions. However, the Fishery Resources (48 – moderate) and Fishing Technology (50 – moderate) domains revealed critical weaknesses, particularly the declining CPUE, high proportion of juvenile catches, and persistent use of destructive fishing practices.

In addition, the key management issues identified include limited stakeholder participation, weak law enforcement, and inadequate implementation of existing fisheries management plans. These issues collectively undermine the ecological foundation of the fishery, despite positive economic outcomes.

Based on these findings, the future sustainable management of grouper fisheries requires an integrated, multidimensional approach. The main recommendations are as follows: 1. Strengthening monitoring and law enforcement through collaborative efforts among institutions and communities to curb destructive and illegal fishing practices. 2. Accelerating the finalization of the Fisheries Management Plan for FMA 713 should incorporate spatial and temporal management options such as protection of spawning aggregation sites (SPAGS). 3. Developing a participatory fish-landing monitoring and data collection system to generate more accurate information on grouper stock status as a basis for adaptive management. 4. Enhancing the socioeconomic resilience of fishing communities through

livelihood diversification and improved financial management capacity to reduce absolute dependence on increasingly pressured resources.

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