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Analysis of Environmentally Friendly Fishing Gear Based on the Code of Conduct for Responsible Fisheries (CCRF) in Tambak Lorok, Semarang City, Indonesia

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ABSTRACT:

Tambak Lorok, Semarang City, is a region with intensive fishing activities. This study aimed to analyze the technical aspects and environmental friendliness level of five fishing gears (stationery lift net, gill net, dragon trap, push net, and mini bottom trawl) using nine criteria from the FAO's Code of Conduct for Responsible Fisheries (CCRF). The descriptive analysis research was conducted from June to August 2024. Data were collected through observation, interviews, and CCRF criteria scoring. Results showed that gill net achieved the highest score (30.86), followed by dragon trap (29.39) and stationery lift net (29.55), categorized as highly environmentally friendly. Push net scored 21.43 (environmentally friendly), while mini bottom trawl scored lowest (17.47), categorized as not environmentally friendly. The study concludes that passive and static gears like gill nets and traps are more aligned with CCRF principles, while active bottom like small bottom trawl require stricter management or modification.

Keywords: CCRF, Environmental Sustainability, Fishing Gear Selectivity, Responsible Fisheries, Tambak Lorok.

1. Introduction

Indonesia's marine fisheries face significant challenges due to unsustainable fishing practices, leading to habitat degradation and potential overfishing. The coastal community of Tambak Lorok in Semarang City represents a typical small-scale fishing hub where diverse fishing gears operate. Among these, gears like small bottom trawl and push net are known for their low selectivity and high environmental impact, potentially causing habitat destruction and high bycatch (Rahmatullah, 2019; Luthfiani et al., 2018). Conversely, gears like gill nets and traps are often considered more selective and less destructive.

The Food and Agriculture Organization (FAO) established the Code of Conduct for Responsible Fisheries (CCRF) as a voluntary framework to promote sustainable fishing practices globally (FAO, 1995). It outlines criteria for environmentally friendly fishing technology, including high selectivity, minimal habitat impact, and low bycatch. Several Indonesian studies have applied CCRF criteria to assess local fishing gears (Firdaus et al., 2017; Ernaldi et al., 2017; Abdulaziz et al., 2018).

Despite existing regulations restricting destructive gears, their use persists in areas like Tambak Lorok due to perceived economic benefits (Chairunnisa et al., 2018; Hakim et al., 2021). This creates a gap between policy, enforcement, and local practice. Therefore, a scientific assessment based on standardized international criteria is crucial for evidence-based management. This study aims to analyze and compare the technical aspects and environmental friendliness level of five dominant fishing gears in Tambak Lorok based on the nine CCRF criteria. The findings are expected to provide concrete recommendations for gear management, policy refinement, and stakeholder engagement to promote sustainable fisheries in the region.

2. Methods

2.1. Study area

This research was conducted in Tambak Lorok, Tanjungmas Village, North Semarang District, Central Java, Indonesia (6°57'6.27"S - 6°56'30.58"S, 110°26'11.19"E - 110°26'17.85"E). Data collection took place from June 25 to August 8, 2024.

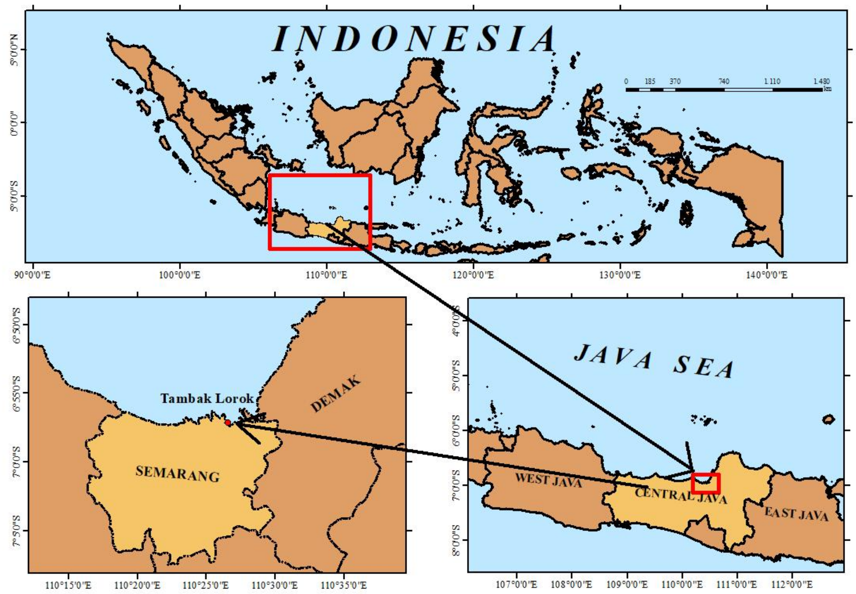

Fig. 1 – Map of Tambak Lorok Semarang

2.2. Research design and data collection

This study employed a descriptive analysis method. Primary data were collected through:

- Direct Observation: Technical specifications of five fishing gears (stationery lift net, gill net, dragon trap, push net, small bottom trawl) and catch composition.
- Structured Interviews: Using questionnaires with 258 fishermen (9 stationery lift net, 100 gill net, 37 dragon trap, 35 push net, 77 small bottom trawl) selected via purposive sampling (30% of each gear's population). Interviews covered all nine CCRF criteria.
- Catch Measurement: Sampling of main catch and bycatch to analyze species composition and size (compared to length at first maturity, Lm).

Secondary data on fleet, fishermen, and production (2019-2023) were obtained from the Semarang City Fisheries Office.

2.3. Data analysis

- Technical Aspects: Included gear construction, operation methods, main catch/bycatch ratio, and size selectivity (comparison of caught fish size with Lm from literature).
- CCRF Scoring Analysis: Each gear was assessed against nine CCRF criteria (Table 1). Each criterion had a scoring range of 1-4. The total score for each gear was calculated using the formula:

$$X = \Sigma Xn / n \qquad (1)$$

Where X = final environmental friendliness score, Xn = total weight score, n = number of respondents.

Scores were categorized as: 28-36 (Highly Environmentally Friendly), 19-27 (Environmentally Friendly), 10-18 (Not Environmentally Friendly), 1-(Very Not Environmentally Friendly).

Table 1 - Summary of Nine CCRF Assessment Criteria

No	Criteria	Description (Score 1-4)
1	High Selectivity	From catching >3 species of vastly different sizes (1) to catching single species of similar size (4).
2	No Habitat Damage	From causing wide habitat damage (1) to being habitat-safe (4).
3	Safe for Fishers	From causing fatalities (1) to being safe (4).
4	High-Quality Catch	From dead and rotten catch (1) to live catch (4).
5	Safe for Consumers	From high health risk (1) to being safe (4).
6	Low Bycatch	From unsellable multi-species bycatch (1) to high-value, <3 species bycatch (4).
7	Low Biodiversity Impact	From killing all life and habitat damage (1) to being biodiversity-safe (4).
8	No Capture of Protected Species	From frequent capture (1) to never captured (4).
9	Social Acceptance	Meeting 1 of 4 conditions (1) to meeting all conditions: low cost, profitable, culturally fit, regulation compliant (4).

3. Results and discussion

3.1. General Condition of Fishing in Tambak Lorok

Data (2019-2023) show fluctuating trends. The number of fishermen increased from 1,038 to 1,274. Gill net and small bottom trawl were the most numerous gears, although small bottom trawl numbers declined from 390 to 256 units, likely reflecting regulatory pressure. Total catch production fluctuated, dropping from 218 tons (2019) to 149 tons (2020) before recovering to 172 tons (2023). This volatility underscores the need for sustainable management to ensure long-term resource and economic stability.

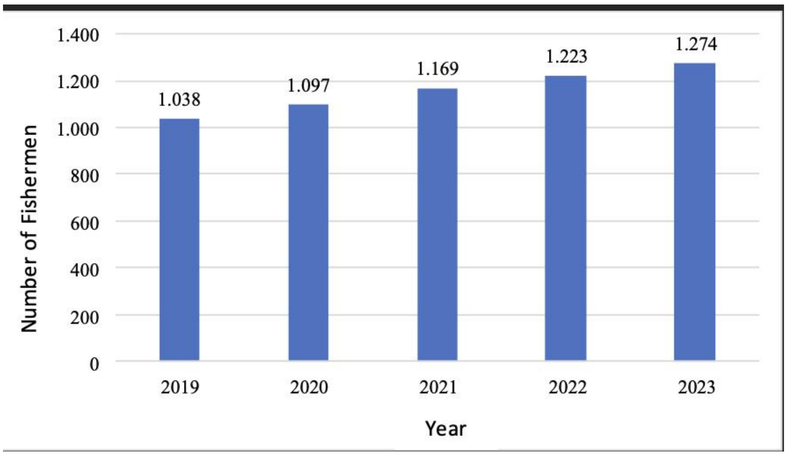

Fig. 2 – Number of Fishermen in Semarang
Source: Marine and Fisheries Office of Semarang (2024)

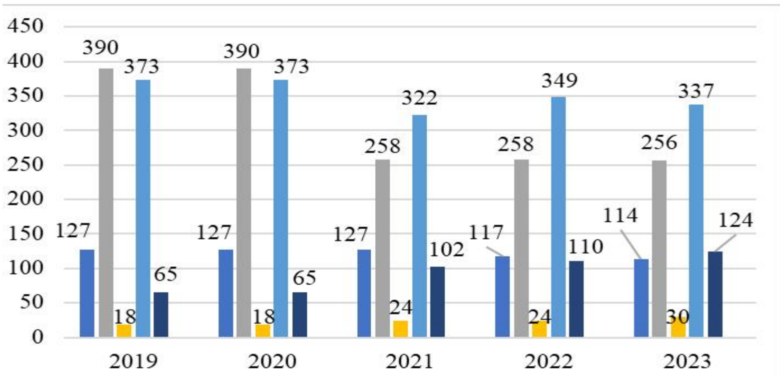

Fig. 3 – Number of Fishing Gear in Semarang
Source: Marine and Fisheries Office of Semarang (2024)

3.2. Technical Aspects of Fishing Gears

3.2.1. Stationery lift net

The stationary lift net is operated in shallow waters (2-5 m). This passive gear uses lamps to attract phototactic species, primarily anchovies and sardines. The net is characterized by a very small mesh size (0.5 cm) and is hauled vertically using a bamboo roller system. Catch analysis revealed a mixed composition. While the aggregated main catch (squid, white shrimp, anchovy) constituted 57% of the sample weight, the single largest component was a by-catch species, white snapper (43%). More critically, size analysis showed that 100% of the sampled individuals from four species (squid, white shrimp, anchovy, and white snapper) were caught below their estimated length at first maturity. This indicates severe growth overfishing, where the gear's efficiency in attracting and catching juveniles undermines stock recruitment, presenting a major sustainability trade-off despite its low habitat impact.

3.2.2. Gill net

The gill net is a passive, drifting gear with a mesh size of 5 cm, targeting species like barracuda and swimming crabs. Its operation relies on fish gilled. The gear showed moderate selectivity, with a by-catch proportion of 77%. The calculated hanging ratio of 0.45 was below the optimal range (0.5-0.7), which may reduce its size selectivity and efficiency. Nevertheless, its passive nature and lack of seabed contact contribute to a lower habitat impact compared to active gears.

3.2.3. Dragon trap

The dragon trap is a passive, collapsible trap operated in shallow waters, targeting crustaceans like mangrove crab and white shrimp. The trap has a mesh size of 0.5 cm. Catch composition was relatively balanced, with main catch (mangrove crab, white shrimp, giant river prawn) making up 51% of the sample. However, size analysis revealed that five out of seven species caught, including the valuable giant river prawn and white shrimp, were below their maturity size. Only mangrove crab and eel-catfish were caught at sustainable sizes. While the trap is considered habitat-friendly, its effectiveness in catching undersized crustaceans highlights a need for potential gear modifications to improve size selectivity.

3.2.4. Push net

The fishing gear is an active push net operated at night, often with light assistance, targeting various shrimp species. It features a graded mesh, with the cod-end having a very small mesh size (1.24 cm). This gear exhibited low selectivity, with by-catch constituting 57% of the total catch and comprising 11 different species. Size analysis was particularly concerning: 11 out of 15 species caught were below their maturity size. As an active bottom-contact gear, push net also poses a risk of habitat disturbance in addition to its selectivity issues.

3.2.5. Small bottom trawl

The fishing gear is an active bottom trawl, explicitly prohibited due to its destructive nature. It uses a small cod-end mesh (0.6 cm) and is dragged, scraping the seabed. As expected, it demonstrated the poorest performance. By-catch was extremely high at 88% of the total catch, comprising 16 different species. The size analysis was the most alarming: 14 out of 18 species caught were below their length at first maturity. This includes commercially important species like mackerel (*Scomberomorus commerson*) and white snapper. The gear's operation fundamentally leads to habitat destruction, high mortality of juvenile fish, and a catastrophic level of growth overfishing, validating its regulatory ban and categorizing it as the least sustainable gear in the study.

3.3. CCRF scoring and environmental friendliness level

The environmental friendliness of the five fishing gears was quantitatively assessed using the nine criteria outlined in the FAO's Code of Conduct for Responsible Fisheries (CCRF). These criteria encompass selectivity, habitat impact, fisher safety, catch quality, consumer safety, bycatch rate, biodiversity impact, capture of protected species, and social acceptance. Based on the scoring methodology, gears are categorized by their total score: 28–36 (Highly Environmentally Friendly), 19–27 (Environmentally Friendly), 10–18 (Not Environmentally Friendly), and 1–9 (Very Not Environmentally Friendly) (FAO, 1995).

The assessment revealed a clear hierarchy in sustainability. The gill net achieved the highest score (30.86), followed by the stationary lift at 29.55 and the dragon trap at 29.39, all three falling into the highly environmentally friendly category. In contrast, the push net scored 21.43, placing it in the environmentally friendly category, while the small bottom trawl received the lowest score of 17.47, categorizing it as not environmentally friendly. This scoring aligns with their technical performance, where passive gears (gill net, dragon trap) scored highest, and active bottom-disturbing gears scored lowest.

The superior score of the gill net is attributed to its high selectivity through adjustable mesh size, minimal seabed impact due to its passive, drifting operation, and strong social acceptance from fishers due to its low investment cost and compliance with regulations (Firdaus et al., 2017; Iskandar & Aji, 2016). Although the stationary lift net also scored highly, it received a lower selectivity score due to its small mesh size (0.5 cm) leading to juvenile catch. However, its stationary nature and lack of seabed dragging secured high scores for low habitat impact and fisher safety. Research by Aprilla et al. (2022) and Risamasu et al. (2019) confirms that gill nets consistently score higher than lift nets in CCRF assessments due to better selectivity and lower ecosystem disturbance.

A significant gap exists between the push net and the small bottom trawl, despite both being active gears. The push net's higher score is primarily due to its relatively better selectivity and lower habitat impact compared to the seabed-scraping small bottom trawl (Pramesthi & Mardiah, 2019). However, the small bottom trawl's critically low score validates existing regulatory bans, as it performs poorly across all criteria, especially selectivity, bycatch, and biodiversity impact, causing widespread habitat destruction and growth overfishing (Subehi et al., 2017). This underscores that even among non-friendly gears, there are degrees of impact that management must address.

In conclusion, the CCRF scoring provides a robust, multi-criteria framework for evaluating gear sustainability. The results confirm that passive and static gears are most aligned with responsible fishing principles. To achieve fishery sustainability, management must promote and incentivize the use of high-scoring gears like gill nets and traps, while rigorously enforcing bans on destructive gears like small bottom trawl and developing mitigation strategies for intermediate gears like push net and stationery lift net, particularly focusing on improving their size selectivity (Fadli et al., 2020).

Table 2 - Final CCRF Scores for Five Fishing Gears in Tambak Lorok

Fishing Gear	Final Score	Category
Gill Net	30.86	Highly Environmentally Friendly
Stationery Lift Net	29.55	Highly Environmentally Friendly
Dragon Trap	29.39	Highly Environmentally Friendly
Push Net	21.43	Environmentally Friendly
Small Bottom Trawl	17.47	Not Environmentally Friendly

4. Conclusion and recommendations

The technical operations of the five gears vary significantly, with small bottom trawl and push net being active bottom-disturbing gears, while gill net, dragon trap, and stationery lift net are more passive/static. Based on CCRF criteria, gill net (30.86), stationery lift net (29.55), and dragon trap (29.39) are highly environmentally friendly. Push net (21.43) is environmentally friendly, while small bottom trawl (17.47) is not environmentally friendly. The low score of small bottom trawl validates existing regulatory bans on such gear. The recommendation from this study is a gradual transition from small bottom trawl and push net to more selective gears. For Future Research: Conduct a detailed socio-economic study to understand the drivers behind continued use of destructive gears and design more effective intervention programs. Long-term ecological impact studies focusing on specific habitats in Tambak Lorok are also needed.

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