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Sustainable Capture Fisheries Optimization for Blue Economy and Fishermen's Welfare in Indonesia

Robert Tambun[1*], Sutrisno[2], Hadi Prasutiyon[3]

[1]Master of Ocean Engineering. Hang Tuah University, Surabaya 60111, Indonesia.

[2,3]Departement of Marine Engineering and Marine Science, Hang Tuah University, Surabaya 60111, Indonesia.

*robert.tambun@hangtuah.ac.id

Abstract

Indonesia's maritime zones, especially the Aru, Arafuru, and Eastern Timor Seas, possess high capture fisheries potential, with an annual sustainable catch limit of 2.1 million tons. Despite this, utilization remains below optimal due to ecological, social, and infrastructural challenges. This study explores how integrating fishing technology and adaptive governance in Indonesia's Fisheries Management Areas (WPPNRI) can enhance fisheries sustainability and support the Blue Economy. Using a qualitative approach and SWOT analysis, key strengths identified include rich biodiversity and supportive policies, while weaknesses involve limited infrastructure and fisher empowerment. Opportunities lie in global demand for sustainable seafood and innovation, yet threats such as illegal fishing and environmental degradation persist. The findings suggest that regionally tailored policies, improved data systems, and inclusive governance are essential for optimizing capturing fisheries and ensuring national food security.

Keywords: Capture Fisheries, Geospatial Integration, Sustainable Blue Economy.

1. INTRODUCTION

Indonesia, as the world's largest archipelagic nation, possesses immense maritime potential, with seas covering around 65% of its total territory [1]. This maritime domain includes vast and diverse ecosystems that are critical not only for national food security but also for global marine biodiversity [2]. According to the 1982 United Nations Convention on the Law of the Sea (UNCLOS), Indonesia's maritime area extends to approximately 3,257,357 km², making it a vital contributor to regional and global marine health [3]. The nation hosts 37% of the world's fish species, as well as high diversity of mollusks, crustaceans, and coral reefs, which form the backbone of its fisheries sector and marine-based economy [4]. These natural resources offer enormous opportunities for fisheries development, marine tourism, and the growth of coastal communities [5].

Despite these advantages, the actual utilization of Indonesia's fishery resources remains far below potential. Marine capture fisheries demonstrate a sustainable production capacity of 6.5–7.3 million tons per year, yet actual catch levels only reach about 73–82% of this capacity due to limitations in technology, governance, and resource management [6]. Inland fisheries and aquaculture sectors are even less developed, facing challenges of low productivity and substandard practices [7]. Major constraints include inadequate infrastructure for cold storage and transport, limited availability of high-quality seed and feed, and inefficiencies within fish processing and value-adding industries [8]. In addition, harmful activities such as overfishing, illegal fishing, and destructive practices like blast fishing cause significant damage to marine habitats and result in economic losses estimated at up to IDR 42 trillion annually [9].

In response, the Indonesian government and stakeholders have promoted the Blue Economy concept, which aims to balance economic growth, environmental sustainability, and social welfare in the use of marine resources [10]. The success of this approach requires robust and adaptive governance, greater adoption of technology at all levels of the fisheries value chain, and the empowerment of small-scale fishers and coastal communities to participate actively in marine resource management [11]. Furthermore, it is critical that

national policies—such as the Fisheries Management Plan (RPP)—are developed based on scientific evidence and tailored to the unique ecological and socio-economic conditions of each region to ensure sustainable fisheries development [12].

2. METHODS

2.1. Method

This study uses a descriptive qualitative method with a focus on literature review and secondary data analysis to explore the potential and challenges of optimizing capture fisheries in Indonesia. The core analytical tool used in this paper is SWOT analysis—an evaluative method designed to assess both internal and external factors that influence capture fisheries management within Indonesia's Fisheries Management Areas (WPPNRI).

- Strengths are analyzed by identifying internal capabilities such as natural marine wealth, fisheries infrastructure, and institutional frameworks that support fisheries development.
- Weaknesses refer to internal limitations, such as underutilized aquaculture potential, low-quality inputs, or regulatory inconsistencies.
- Opportunities include external conditions such as growing global demand for sustainable seafood, government support for the Blue Economy, and technological innovations.
- Threats are examined in relation to risks such as illegal, unreported, and unregulated (IUU) fishing, environmental degradation, and global market fluctuations.

The application of SWOT analysis is aimed at formulating strategic recommendations for sustainable fisheries development, particularly in line with the principles of the Blue Economy and national food security.

2.2. Approach

This paper adopts a comprehensive empirical-literal approach, utilizing data sourced from government reports, academic journals, research findings, and official publications from relevant institutions (e.g., Ministry of Maritime Affairs and Fisheries, FAO, and BPS Indonesia). The data are reviewed and interpreted through the lens of policy frameworks, theoretical perspectives on sustainable fisheries, and environmental economics.

The analysis is grounded in a food security perspective, examining the extent to which improved fisheries governance and technology adoption can contribute to the socio-economic welfare of fishing communities and support national development goals. Key findings are synthesized to provide a contextual understanding of Indonesia's current fisheries landscape and offer recommendations for future policy direction.

2.3. Data / Facts

- Capture Fisheries Productivity in Indonesia

The productivity of capture fisheries in Indonesia fluctuates due to the high availability of fishery resources. In 2021, the total capture fisheries production, including both marine capture fisheries and inland public waters (PUD) reached 7,224,500.59 tons.

This figure shows an increase compared to 2020, when production was approximately 6.98 million tons. However, when compared to 2019, the production volume in 2021 showed a decline. In 2019, capture fisheries production was 7.33 million tons.

Table 1. Volume and Value of Fisheries Production in Indonesia (2017–2021)

Field	Sub field	2017	2018	2019	2020	2021
Total Fisheries Production Volume (Tons)		23.186.443,34	23.049.854,96	22.760.946,74	21.834.105,35	21.872.810,30
Capture Fisheries	Total Capture Fisheries	7.071.452,63	7.361.120,91	7.335.322,12	6.989.090,44	7.224.500,59
Capture Fisheries	Subtotal Marine Capture Fisheries	6.603.630,52	6.701.834,01	6.630.123,09	6.494.140,38	6.767.564,83

Field	Sub field	2017	2018	2019	2020	2021
Capture Fisheries	Subtotal Inland Public Waters (PUD) Capture Fisheries	467.822,11	659.286,90	705.199.03	494.950,06	456.935,76
Aquaculture	Total Aquaculture	16.114.990,71	15.688.734,06	15.425.624,63	14.845.014,91	14.648.309,71
Aquaculture	Subtotal Marine Aquaculture	9.884.669,07	9.267.869,28	8.617.168,20	8.499.280.75	7.316.856,35
Total Fisheries Production	Volume (Tons)	412.253.551	389.523.179	363.081.177	392.647.818	384.490.782
Capture Fisheries	197.337.071	218.796.972	201.879.368	186.564.647	194.856.953	7.224.500,59
Capture Fisheries	184.620.257	204.213.404	180.259.441	171.529.686	179.580.859	6.767.564,83
Capture Fisheries	12.716.814	14.583.568	21.619.926	15.034.962	15.276.094	456.935,76
Aquaculture	187.153.712	193.456.579	187.643.811	176.516.530	197.790.865	14.648.309,71
Aquaculture	33.656.157	29.981.826	29.995.292	26.574.475	26.046.394	7.316.856,35

Source: KKP, 2023.

The decrease in production during 2020 and 2021, compared to 2019, was partly due to the COVID-19 pandemic, which resulted in mobility restrictions imposed by the government. Tables 1 and 2 provide an overview of the volume and value of fisheries production in Indonesia from 2017 to 2021, as well as the capture fisheries production volume per WPP from 2019 to 2021.

Table 2. Volume of fish catch production per WPP in 2019 – 2021

Province	2019	2020	2021
TOTAL (TONS)	6.630.123	6.494.140	6.767.565
WPP-RI-571	476.447	500.844	417.477
WPP-RI-572	779.756	680.725	628.494
WPP-RI-573	592.161	538.551	526.560
WPP-RI-711	854.515	838.280	870.863
WPP-RI-712	1.086.135	1.130.106	1.268.583
WPP-RI-713	808.007	824.521	892.858
WPP-RI-714	630.596	569.819	652.416
WPP-RI-715	812.888	782.279	812.128
WPP-RI-716	238.848	266.111	243.372
WPP-RI-717	149.651	161.617	199.976
WPP-RI-718	181.227	184.639	242.094
Indian Ocean High Seas	5.972	16.649	12.744
Pacific Ocean High Seas	13.922	0	0

Source: KKP, 2023

- Fishermen in Indonesia

Fishermen are everyone whose livelihood is fishing. In Law No. 7 of 2016, fishermen are divided into the categories of small fishermen, traditional fishermen, labor fishermen and owner fishermen. Small fishermen are fishermen who catch fish with the aim of meeting the needs of life, either using fishing vessels with a maximum size of 10 Gros Ton (GT) or not using fishing vessels.

Traditional fishermen are fishermen who fish in waters that are traditional fisheries rights. Meanwhile, labor fishermen are fishermen who provide labor to participate in the fishing business, and for owner fishermen are fishermen who own fishing vessels and use them actively for the fishing business.

Table 3. Number of fishers by capture fisheries sub-sector in 2010-2021

No. of fishers	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total (people)	2.620.277	2.755.178	2.748.908	2640.095	2.739.883	2.702664	2643.902	2667.572	2.637.269	2736.218	2.849.473	2.925.818
Sea fishers	2.162.442	2265.213	2.278.388	2164.969	2.210.195	2275.139	2.265.859	2289.529	2.292.024	2088.959	2.359.064	2359.264
Sea fishers	457.835	489965	470.520	475 126	529.688	427.525	378.043	378043	345.245	647.259	490.409	566.554

Source: KKP, 2023.

Based on data from the Ministry of Maritime Affairs and Fisheries (KKP) in 2021, the number of fishermen in the capture fisheries sub-sector in Indonesia was 2,925,818, consisting of sea fishermen and PUD fishermen. The number of fishermen is the highest number during the period 2010 to 2021. The following table shows the number of fishermen by capture fisheries sub-sector in 2010-2021 and data on fishermen in capture fisheries sub-sector based on WPPNRI.

Table 4. Data of fishermen in capture fisheries sub-sector based on WPPNRI

Wpp Sea Capture Fishermen	2019	2020	2021
TOTAL (TONS)	2736.218	2.849.473	2.925.818
WPP-RI-571	147.876	161.270	143.377
WPP-RI-572	257.624	219.124	213.087
WPP-RI-573	275,881	260.402	243.710
WPP-RI-711	101.956	258.487	251014
WPP-RI-712	337.476	377.592	400.818
WPP-RI-713	283.027	381.218	394.072
WPP-RI-714	301689	249.213	231.605
WPP-RI-715	159.711	234.369	252.281
WPP-RI-716	71656	89.817	78:383
WPP-RI-717	58-860	50.640	59.444
WPP-RI-718	42 243	65.023	75.036.
Indian Ocean high seas	945	11.909	15.260
Pacific Ocean high seas	15	0	1.177

Source: KKP, 2023

• Fishermen Exchange Rate (NTN)
Fishermen's exchange rate is an indicator to determine the exchangeability of fish catches for goods/services needed by fishermen to meet production needs or household consumption. Below is the NTN graph for 2014-2022 based on the CTF. The NTN shown is the NTN in December (Quarter IV) for each year.
Based on the NTN data, it can be seen that the NTN in 2022 has decreased when compared to December 2021. When compared to 2019, the NTN in 2022 experienced a significant decline. NTN is above 100, which means that through their business fishermen are able to meet the needs for production (fishing) and also the basic needs of their households.
However, it should be noted that when looking at NTN per province, there are still many provinces in Indonesia whose NTN is deficit or below 100. NTN below 100 means that fishermen's income is insufficient to meet production needs (fishing costs) and basic household consumption. As in 2020, based on BPS data, 55.88% of provinces in Indonesia experienced NTN deficits.

Fishermen's Exchange Rate - 2014-2022 (Trivulan IV)

Figure 1 1. NTN 2014 – 2022
Source: KKP, 2023.

- World Fish Needs

Fish is one of the food commodities consumed by the world's population. In some countries, fish has become a staple food, while in some other countries it is only a complementary food. In 2021, based on the report of the Organization for Economic Cooperation and Development (OECD), global fish consumption was 180.7 million metric tons, and it is projected to increase to 200.6 million metric tons by 2030. Below is a graph of global fish consumption from 2018 to 2021, and its projection until 2030.
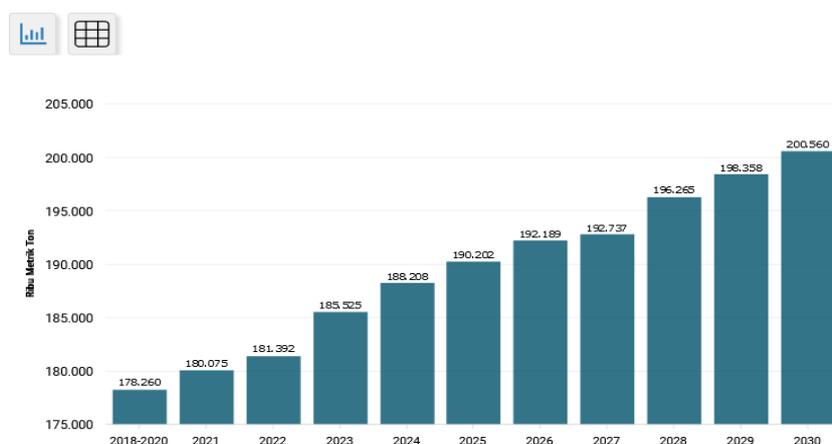
Projected World Fish Consumption (2018-2030)

Figure 2. World fish consumption from 2018 to 2021 and projection up to 2030

- IUU Fishing Index

The IUU Fishing Index is an index to measure the exposure and effectiveness of countries in addressing IUU fishing practices. The index provides an IUU fishing score for all coastal states between 1 and 5 (1 being the best, and 5 being the worst). The index measures countries' vulnerability, prevalence and response to IUU fishing24. In 2021, the global IUU Fishing index was 2.24. This is an improvement compared to 2019, which amounted to of 2.29. For Indonesia, in 2019 the IUU Fishing Index was 2.70 and for 2021 it was 2.55. This means that the level of IUU Fishing exposure is lower and the handling is better, but still below the global IUU Fishing index achievement.

Indonesia
2021 country results

IUU score
2.55

2.75 2.83 1.89 2.60
Coastal Flag Port General
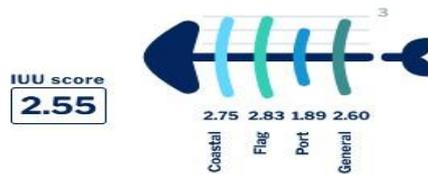
IUU score ranks
2021 World overall IUU score is 2.24

World ranking
20 of 152 countries ↓ -5

Asia ranking
6 of 20 countries ↑ 1

East Indian Ocean ranking
1 of 9 countries ↑ 1

Western Pacific ranking
7 of 29 countries — 0

Figure 3. Indonesia's IUU Fishing Index

The measurement of IUU Fishing is calculated from several indicators including coastal indicators, flags (vessels), ports and general scores. In the coastal indicator, among others, it is assessed from the EEZ area, license of foreign vessels operating in the EEZ, MSC certified fisheries. The flag score is assessed on IUU-listed vessels, FAO regulatory compliance agreements, foreign registered vessels, and provision of vessel data, among others. On the port score, fishing ports, port visits by fishing vessels are assessed. In the general score, among others, it is assessed from IUU Fishing regulations, ratification of global fisheries regulations.

- Number of Ships

Vessels according to Law No. 45 of 2009 concerning Fisheries are defined as ships, boats, or other floating devices used for fishing, supporting fishing operations, fish farming, fish transportation, fish processing, fisheries training, and fisheries research/exploration. Based on CTF data, there were 1,004,060 marine capture fisheries vessels in 2021. The number of vessels increased compared to 2019, which only amounted to 936,249, but decreased when compared to 2020, which amounted to 1,171,332. The number of vessels is dominated by boats without motors, outboard motor boats, and vessels up to 10 GT28. The following is data on marine capture fisheries vessels in Indonesia:

- Dilemma of Capture Fisheries Management in Indonesia

Exploitation efforts of fisheries resources in Indonesia in various facts show a reduction in environmental balance through overfishing activities. Overfishing is a term or condition for water areas where fish stocks have been overfished and exceed the recovery capacity of these fish resources. According to Dahuri (Watissa, 2014:4), indicators that can be used to indicators that can be used to measure whether an area is overfished include a higher total yield of fish resources, a tendency to decrease fish catches, and a decrease in the average size of fish caught in the fishing area. Several Indonesian marine areas, including the Malacca Strait, East Sumatra Waters, Java Sea, and Bali Strait, are experiencing declining catches and more overfished fishing grounds. catches and more distant fishing grounds, causing a 68.91% annual decline in fishermen's catches. The decline in income from fishermen's catch was 68.72%. Other data shows that coral reefs are threatened due to overfishing caused by the use of bombs to catch fish. fish. In addition to the rampant overfishing, fishing using tools that are not in accordance with the rules is also rampant, such as the use of explosive bombs and potassium.

- History of WPPNRI

WPPNRI in Article 1 of the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 18/Permen-Kp/2014 concerning the State Fisheries Management Area of the Republic of Indonesia is defined as a fisheries management area for fishing, fish farming, conservation, research, and development of fisheries.

fisheries. The division of fisheries management areas is motivated by the differences and diversity of regional characteristics, fish resources, sea toponyms, and seabed morphology as well as considering regional autonomy and Indonesia's maritime boundaries. The differences in these characteristics require different approaches approach in its management. In more detail, the objectives of the WPPNRI division are as follows:

1) Facilitate monitoring, classification and follow-up plans for fisheries resource management;
2) Optimizing management for sustainability and preservation of resources;
3) Developing supporting infrastructure according to resource characteristics so that it is more appropriate;
4) Develop partnerships between stakeholders on the basis of mutual need;
5) Expanding opportunities for innovation, local entrepreneurship, and trade development through strong networks.

WPPNRI mapping was first conducted in 1999 through the Decree of the Minister of Agriculture No.995/Kpts/IK 210/9/99 on Potential Fish Resources and Allowable Catch (JTB). It divides SDI management into 9 WPPs, namely (1) Indian Ocean Waters; (2) Sulawesi Sea and Pacific Ocean; (3) Seram Sea and Tomini Bay; (4) Arafuru Sea; (5) Banda Sea; (6) Flores Sea and Makassar Strait; (7) Java Sea; (8) Malacca Strait; and (9) South China Sea.

The re-mapping of WPPNRI was conducted again in 2009 taking into account the digital national coordinate system, the latest segment of the EEZI border, naming and numbering in accordance with international standards. The mapping resulted in 11 WPPs as outlined in the Minister of Marine Affairs and Fisheries Regulation No. Per.01/Men/2009 and updated again based on the Minister of Marine Affairs and Fisheries Regulation No.18/PERMEN-KP/2014 concerning Fisheries Management Areas of the Republic of Indonesia. Referring to the Food and Agriculture Organization (FAO) "Fisheries Area" standard and for Indonesia is included in Fishing Area 57 and 71.

The following is the division of WPPNRI based on the Regulation of the Minister of Maritime Affairs and Fisheries

Fisheries No.18/PERMEN-KP/2014:

1) WPP-RI 571 covers the waters of the Malacca Strait and the Andaman Sea;
2) WPP-RI 572 covers the waters of the Indian Ocean west of Sumatra and the Sunda Strait;
3) WPP-RI 573 covers the waters of the Indian Ocean south of Java to the south of Nusa Tenggara, the Sawu Sea, and the West Timor Sea;
4) WPP-RI 711 covers the waters of the Karimata Strait, Natuna Sea, and South China Sea;
5) WPP-RI 712 covers the waters of the Java Sea;
6) WPP-RI 713 covers the waters of the Makassar Strait, Bone Bay, Flores Sea, and Bali Sea;
7) WPP-RI 714 covers the waters of Tolo Bay and Banda Sea;
8) WPP-RI 715 covers the waters of Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea and Berau Bay;
9) WPP-RI 716 covers the waters of the Sulawesi Sea and the North of Halmahera Island;
10) WPP-RI 717 covers the waters of Cendrawasih Bay and the Pacific Ocean;
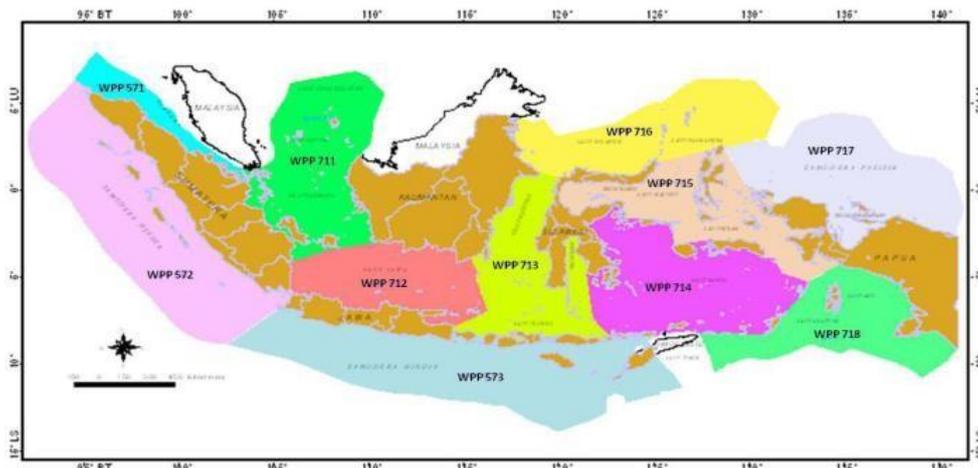11) WPP-RI 718 covers the waters of the Aru Sea, Arafuru Sea, and Eastern Timor Sea.

Figure 4. WPPNRI division

The government has also projected the potential of fish resources in each WPP as outlined in the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 50 of 2017 which has been updated in 2022 through the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 19 of 2022 concerning Estimates of Fish Resource Potential, Number of Allowable Fish Catches, and Utilization Rate of Fish Resources in the State Fisheries Management Area of the Republic of Indonesia.

3. RESULTS AND DISCUSSION

In line with national development goals, the integration of Blue Economy principles into WPPNRI-based fisheries management seeks to diversify income sources while protecting marine ecosystems [13]. This approach emphasizes not only capture fisheries but also the development of creative industries, marine tourism, and aquaculture, especially in areas like the Riau Islands and the Anambas Archipelago [14]. However, the enforcement of sustainable practices within WPPNRI often encounters obstacles, including weak regulatory implementation and limited capacity for monitoring and surveillance, which in some cases have led to illegal, unreported, and unregulated (IUU) fishing activities [15].

The Indonesian government has addressed these challenges through specific national policies, such as the National Action Plan for Supervision and Handling of Destructive Fishing Activities, which outlines steps to strengthen control overfishing practices and preserve marine biodiversity [16]. Complementing this, the Strategic Plan of the Ministry of Marine Affairs and Fisheries aims to enhance institutional capacity, promote adoption of technology, and improve coordination among stakeholders [17]. The application of an ecosystem-based approach in fisheries management as implemented in regions like Kakuluk Mesak District demonstrates efforts to balance resource utilization with conservation [18].

Moreover, the economic multiplier effects of well-managed marine sectors are significant, contributing to job creation, food security, and regional stability [19]. In the context of capture fisheries, marketing strategies—such as those applied to niche products like shrimp petis—illustrate the potential for value addition and local economic empowerment [20]. These initiatives, if scaled up, can help strengthen Indonesia's economic resilience and support sustainable coastal development.

3.1. Overview of WPPNRI-Based Capture Fisheries Management

- Capture Fisheries Management Policies

The Strategic Plans of the Directorate General of Capture Fisheries for 2015–2019 and 2020–2024 highlight two core objectives: sustainability of fishery resources and improvement of human resource quality within fishing communities. These goals align with Sustainable Development Goal 14 (Life Below Water) and Indonesia's Blue Economy policy—focusing on ecosystem preservation, value-added economic contributions, employment, and investment growth [21].

Law No. 32 of 2014 on Maritime Affairs and Presidential Regulation No. 16 of 2017 on Indonesian Maritime Policy further emphasize that central and regional governments must manage marine resources sustainably, based on the principles of the blue economy, which integrates land-sea development while respecting environmental capacity [22].

- Phases of Fisheries Control Policy in Indonesia
Indonesia's fisheries control policies can be divided into two eras:
a. Conventional Catch Control (Unmeasured)
This approach focuses on licensing without vessel quotas. Regulations are limited to vessel numbers, sizes, and gear types. Pre-production PNBP (Non-Tax State Revenue) calculations are made without considering actual catch, which often leads to inaccuracies and can cause overpayment or underpayment. This method can encourage a "race to fish," favoring larger commercial actors and disadvantaging small-scale traditional fishers. Although it provides easy entry into the fishing industry, this policy risks overfishing and is misaligned with sustainability goals [23].

b. Measured Fishing Control (PIT)

Introduced through Government Regulation No. 11 of 2023, measured fishing (PIT) is a response to previous policy weaknesses—overexploitation, IUU (Illegal, Unreported, Unregulated) fishing, and unfair PNBP. PIT aims to ensure:

- Social justice by increasing fishermen's welfare.
- Resource conservation by preventing overfishing.
- Economic growth in the fisheries sector and regional development.

The PIT system introduces controlled quotas, based on scientific data, and integrates pre- and post-production PNBP. It also mandates local crew use, domestic market support, fishing gear specifications, and designated landing ports to ensure accurate reporting and regional benefits [24].

3.2. WPPNRI Zoning in PIT Policy

The PIT policy divides WPPNRI into three main zones:

1. Fishing Industry Zones – Offshore areas (beyond 12 nautical miles) and high seas allocated for industrial fishing through contract systems.
2. Local Fishermen Zones – Nearshore waters designated for small-scale, local fishermen using sustainable practices.
3. Spawning and Nursery Ground Zones – Protected areas for fish reproduction and nurturing, with limited use under strict conditions.

This zonation supports sustainable exploitation, regional economic balance, and long-term fish stock preservation.

3.3. Strengths and Weaknesses of PIT Policy

Advantages:

- Enhance fish stock sustainability and marine health.
- Improves data accuracy through monitored catch quotas and regulated ports.
- Promotes regional economic equity via localized landing ports.
- Aligns with the blue economy model (as supported by the World Bank).

As per available data, Indonesia's SDI (Fish Resource Potential) shows alarming overexploitation: 53 WPPNRI areas are fully exploited, 35 overexploited, and only 11 moderately exploited. The PIT policy offers a solution to this crisis by imposing quotas and encouraging equitable resource sharing [25].

Disadvantages:

- Higher entry barriers due to stricter licensing and quota limits.
- Risk of illegal dumping at sea when quotas are exceeded.
- Potential challenges in transitioning small-scale fishers to new compliance standards.

While relatively new in Indonesia, similar quota-based systems have been adopted in countries such as the EU, Iceland, Canada, Australia, New Zealand, the United States, and on a trial basis in China.

3.4. Strategic Actions in WPPNRI-Based Management

To ensure effective WPPNRI-based fisheries management, the government has taken several initiatives:

1. Preparation of Fisheries Management Plans (FMPs) for each WPPNRI region.
2. Establishment of Regional Fisheries Management Institutions (LPPs).
3. Policy Benchmarking with Leading Nations, notably China, the world's top fisheries producer.

For instance, with a smaller EEZ (2.28 million km²) compared to Indonesia (6.15 million km²), China still leads in production with 11.77 million tons (2020) versus Indonesia's 6.4 million tons [26]. China transitioned from open-access fisheries to quota-based management—a model that Indonesia could learn from to increase production while preserving marine ecosystems [27].

4. CONCLUSION

WPPNRI-based capture fisheries management aims to adapt policies to the characteristics of Indonesia's marine areas, to increase the effectiveness of fisheries resource management and maintain ecosystem sustainability. The division of 11 WPPs allows for the implementation of more measurable policies, such as Measured Fishing (PIT), the preparation of Fisheries Management Plans (FMP), and the establishment of Fisheries Management Institutions (LPP). However, although these policies have increased the productivity

of the fisheries sector, fishermen's welfare is still not optimal, and fisheries resource management still faces economic, social, ecological, and institutional challenges that need to be addressed.

The main problems in the management of capture fisheries include the low competitiveness of fisheries products, limited access to capital, as well as marginalization of small-scale fishers and social conflicts. In terms of ecology, challenges include overexploitation of fish resources, IUU fishing, and the impact of climate change. In addition, weaknesses in data collection systems and law enforcement hinder the optimization of management. Therefore, WPPNRI-based management strategies are implemented through economic, social, ecological, and institutional approaches. These approaches include improving the efficiency of small-scale fisheries businesses, empowering fishers, strengthening ecosystem-based policies, and improving data collection systems and regulations.

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