

Driving Factors of the Marine Capture Fishery Production Economy and Resource Sustainability

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ABSTRACT

Purpose: This study examines the effects of fleet size, number of fishermen, and the Fishermen's Exchange Rate on marine capture fishery production, with fishing households and fish consumption as mediating variables.

Design/methodology/approach: This study uses panel data from 33 provinces during 2010–2020 and applies regression-based path analysis to test both direct and indirect effects among the variables.

Findings/Results: The results show that fleet size and number of fishermen have positive effects on fishery production, while the Fishermen's Exchange Rate has a significant negative effect. Fishing households show a mediating role depending on production and distribution conditions, while fish consumption contributes to production through demand pressure.

Originality/Value: This study highlights the interaction between economic, household, and demand-side factors in shaping fishery production. The findings suggest that fisheries policy should integrate productivity, distribution efficiency, and sustainability considerations.

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1. Introduction

Indonesia has substantial marine resource potential, with oceans covering around 70% of its territory. This is reflected in its fisheries capacity, with production rising from 6.2 million tons in 2015 and targeted to reach 6.9 million tons by 2019 (Katadata, 2016a). In Q3 2018, the fisheries sector contributed IDR 98.07 trillion to GDP (current prices). Despite continued growth, expansion slowed from over 7% in early 2017 to below 4% by Q3 2018 (Katadata, 2019). Concerning the contribution of capture fisheries to the national economy, this is in line with the research by Espinasse et al (2023), That in northern Norway, coastal fisheries are a primary industry and also contribute to the country's economic development.

Marine capture fisheries are renewable resources whose economic utilization is limited by biological regeneration. Output depends not only on conventional inputs such as vessels, labor, and technology but also on the interaction between fishing effort and stock availability. Without effective management, open-access systems tend to lead to overfishing, resulting in resource depletion and reduced long-term economic returns.

Marine capture fishery output is determined by key inputs such as vessel capacity, labor, technology, and operating costs, which collectively define fishing capacity and effort. In general, increases in these inputs lead to higher catches, particularly when fish stocks are abundant and ecosystem conditions are favorable (Lindawati & Rahadian, 2016, Suryana et al., 2013). Other research by Reza Septian Pradana (2020), The quantity of motorized vessels, non motorized boats, and fishing gear positively and significantly influence marine capture fishery production, whereas the number of outboard motorboats has a significant negative impact on production. Then research by Neneng & Suartini (2016) Fishing capacity reflected in the number of vessels and fishermen has a significant impact on Indonesia's fishery production, underscoring its critical role in determining output. Thus, adequate fleet size and appropriate fishing equipment are essential to enhance marine capture fisheries. Evidence from Norwegian bluefin tuna fisheries highlights persistent challenges, including suboptimal vessel specifications, high opportunity costs, and variable fishing efficiency (Sistiaga et al., 2025).

In Indonesia's marine capture fisheries, higher production depends on increased inputs; however, output gains are not always proportional due to the law of diminishing returns. As fishing effort intensifies amid declining fish stocks, catch per unit effort falls, reflecting both economic and ecological limits to resource exploitation (Suharto & Khalindra, 2017).

A concurrent decline in the price index received by fishermen and an increase in the price index they pay can significantly reduce the Fishermen's Exchange Rate (NTN). This decline indicates weakened purchasing power, as fishermen face rising operational and living costs while income from catches decreases. Research results by Tikadar et al (2022) Intervention measures are necessary, such as promoting livelihood diversification through training programs, enhancing social infrastructure, providing financial assistance, and enforcing fisheries regulations to boost the income and resilience of fishing communities. This is in line with research on the sustainability of capture fisheries utilization by Hermanto et al (2018), Pulu et al (2010), Sobari et al (2018) Optimizing catches and economic returns must prioritize resource sustainability, as increased fishing effort is constrained by fish population dynamics and ecosystem capacity. Moreover, capital, operational costs, and trip duration significantly influence fishermen's income, with capital and costs exerting partial effects (Darmawanto et al., 2020). Furthermore, Alam & Yousuf (2024), Government support and effective fisheries law enforcement are crucial for raising fishermen's incomes. Integrated investment in

infrastructure, social capital, education, technology, and credit is essential to increase income, reduce poverty, and sustain livelihoods (Xu et al., 2023).

Rapid increases in production inputs can intensify competition between large and small-scale vessels, incentivize illegal fishing, and encourage environmentally harmful gear use. These pressures degrade marine ecosystems, disrupt fish reproduction, and risk species depletion or extinction.

A study by the Marine Research and Development Agency of the Ministry of Marine Affairs and Fisheries and the University of California, Santa Barbara, finds that without measures to curb illegal, unreported, and unregulated (IUU) fishing, Indonesia's marine fish biomass could decline by up to 81%, reducing fish availability in its waters (Katadata, 2016b). A similar trend occurs in eastern Indonesia, where marine ecosystems are degrading, with annual losses from coral reef damage reaching IDR 80.5 billion highest in the waters of Buton, Southeast Sulawesi. Destructive practices such as cyanide and blast fishing damage habitats and disrupt reproduction, yielding short-term gains but substantial long-term losses (katadata, 2016). According to Solarin et al (2024) Shocks to fishery production and its components tend to be persistent, necessitating long-term policy responses to address sectoral disturbances. This is also in line with the research Tsirimokos et al (2025) That well-targeted policy formulations are needed to support the sustainability of the fisheries sector.

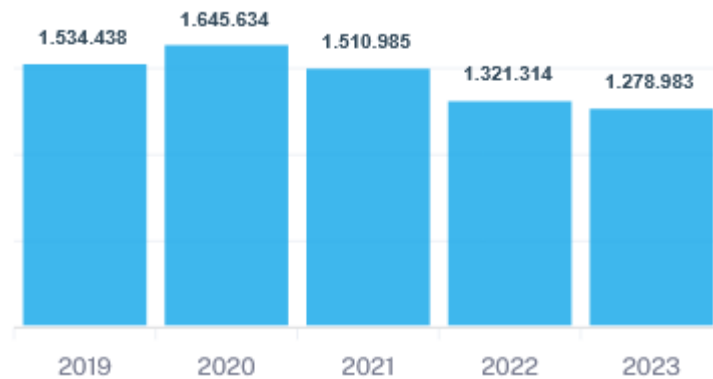
In the short term, increased fishing effort can raise catches; however, from a long-term ecological perspective, excessive effort risks overfishing when it exceeds the regenerative capacity of fish stocks. In fisheries bioeconomics, this is captured by the concept of Maximum Sustainable Yield (MSY), which defines the optimal effort needed to sustain production over time.

In natural resource economics, this reflects the tragedy of the commons: in open-access fisheries, weak regulation and unclear property rights drive excessive effort, accelerating depletion and reducing long-term benefits. Thus, sustainability depends not only on production factors but also on strong management institutions. Implementing measured fishing policies can enhance fishermen's welfare while conserving resources by sustaining stocks, optimizing fleet size, improving data accuracy, supporting efficient port based industries, promoting equitable regional distribution, and providing long-term investment certainty (Trenggono, 2023).

Beyond ecological aspects, capture fisheries sustainability is closely tied to fishermen's welfare, commonly measured by the Fishermen's Exchange Rate (NTN), which reflects the balance between income and household expenses. Ideally, increased production should promote not only economic growth but also improvements in fishermen's welfare. Quiros et al (2018) The study finds that small-scale fisheries are declining, undermining food security and employment in coastal communities; catches with the highest biomass do not yield the greatest market value; and high-value species continue to be harvested at low biomass levels. Fishing households (RTP) with limited capital often rely on inefficient or harmful gear, contributing to resource depletion and stagnant or declining output. Limited skills and weak post-harvest handling further reduce product quality and value added, ultimately constraining income. Salehe et al (2024) The study finds that fishery entrepreneurs exhibit strong pro-sustainability orientations but face limited government support. Entrepreneurial values, innovation, proactiveness, and regulatory frameworks significantly influence the sustainability of fishery businesses. This is in line with the research findings Garren et al (2021)

A fundamental shift in the regulation of fisheries technology is needed to enable more responsive and effective management.

Figure 1. Growth of Capture Fishery Households in Indonesia 2019-2023



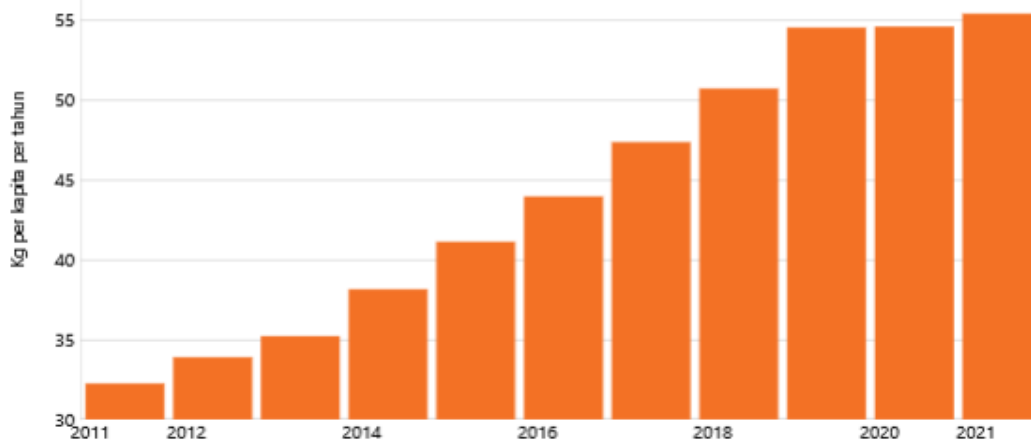
Source: KKP.go.id

Figure 1 indicates an initial increase in fishing households from 1,534,438 to 1,645,634 (7.25%), likely driven by policy support and economic incentives. However, from 2020 to 2023, the number declined consistently to 1,510,985 (-8.18%) in 2021, 1,321,314 (-12.55%) in 2022, and 1,278,983 (-3.21%) in 2023. This trend may reflect livelihood shifts, urbanization, and declining catch availability, alongside ecological pressures, overfishing, regulatory changes, and technological adoption that reduces labor demand.

Previous studies find that the Fish Consumption Rate (AKI) has a positive and significant effect on the economic growth of Indonesia's fisheries sector (Marjusni & Idris, 2023). A high fish consumption rate (AKI) creates strong market demand. Research by Elzaki (2024) The findings confirm positive links between fish exports and GDP, and between fish imports and food security, creating pressure to increase production. In response, aquaculture plays an increasingly vital role in meeting rising global demand driven by economic and demographic growth (Tran et al., 2022).

Over the past decade, Indonesia's fish consumption has trended upward, rising from 32.25 kg per capita in 2011 to an increase of about 69.17% by 2021. The highest annual growth occurred in 2014 (8.32%, 38.14 kg per capita), while the lowest was in 2020 (0.11%, 54.56 kg per capita), as shown in Figure 2.

Figure 2. Fish Consumption Rate in Indonesia 2011-2021



Source: Databoks (2022)

When fish stocks are abundant, output can expand to meet demand; under depletion, rising demand intensifies fishing pressure and accelerates long-term declines. Evidence from Zambia points to a growing supply gap and increasing reliance on imports. Import tariffs have proven ineffective due to low substitutability, while higher import taxes risk regressive effects by raising prices for low-income consumers (Tran et al., 2019).

According to Sumarjo and Santosa (2019), Inequitable product distribution distorts economic outcomes, with export oriented and large-scale processing systems limiting benefits for small-scale fishers despite continued resource pressure. In contrast, inclusive and efficient distribution enhances local value addition, reduces post-harvest losses, and supports more sustainable fishing practices. Thus, downstream-oriented policies spanning post-harvest handling, processing, marketing, distribution, quality control, certification, and consumption are essential for value creation and supply chain strengthening (Tengah, 2025).

Fish consumption in Indonesia remains below its fisheries potential. Per capita consumption increased from 30.48 kg/year in 2010 to 38.1 kg/year in 2014 (5.78% growth), while availability rose from 38.39 to 51.8 kg/year (7.85% growth). This gap is driven by limited public awareness of fish's nutritional benefits, inefficient distribution systems, and inadequate infrastructure (Djunaidah, 2017). Fish prices are driven by consumption. Strong demand elevates prices and encourages greater fishing effort despite declining catch per unit effort. Species-specific preferences further intensify exploitation; when targeting vulnerable or slow-growing species, sustained demand accelerates depletion and leads to sharp production declines.

Expansion of fleets and labor in open-access or weakly regulated fisheries accelerates overfishing and stock depletion. While output may increase initially, effort beyond MSY reduces stock levels, lowers catch per unit effort, and ultimately depresses total production. Coupled with rising costs, this erodes the Fishermen's Exchange Rate, signaling declining efficiency and fisher welfare under unsustainable practices.

Community-based management is an effective approach to strengthening fisheries governance, reducing conflicts, and sustaining marine and coastal resources. Its success hinges on community participation, local capacity, and consistent engagement (Widarmanto, 2018). The interaction between fishing household conditions and fish consumption shapes long-term capture fishery trends. Demand-driven consumption can induce higher output, potentially through unsustainable practices, while socio-economic status mediates these responses, affecting both production and sustainability.

Marine capture fisheries hold significant economic potential, but balancing production optimization with resource sustainability remains challenging. Most studies treat production efficiency and socio economic factors separately, with limited integration of inputs, sustainability, and fishermen's welfare within a unified framework.

This study analyzes the drivers of marine capture fishery production by linking production inputs with resource sustainability and fishermen's welfare. It aims to inform policies that balance economic output and environmental conservation, emphasizing the mediating roles of fishing households (MSMEs) and fish consumption (domestic demand).

2. Literature Review & Hypothesis Development

The research hypothesis based on the background of the problem that has been described is simply structured as follows :

H1. Fishing fleets and the number of fishermen positively influence marine capture fishery production.

- H2.** Fishing fleets and the number of fishermen positively influence fishing households (RTP).
- H3.** The Fishermen’s Exchange Rate (NTN) positively influences fish consumption and marine capture fishery production.
- H4.** Fishing households (RTP) positively influence fish consumption and marine capture fishery production.
- H5.** Fish consumption positively influences marine capture fishery production.
- H6.** Fishing households (RTP) mediate the relationships between fishing capacity variables (fishing fleets and fishermen) and marine capture fishery production.
- H7.** Fish consumption mediates the relationship between the Fishermen’s Exchange Rate (NTN) and marine capture fishery production.
- H8.** Fishing households (RTP) and fish consumption rate (AKI) sequentially mediate the relationships between fishing capacity variables and marine capture fishery production.

3. Methodology

The approach used in this research is quantitative (Creswell & Creswell, 2018), by using linear regression analysis and path analysis. This study uses secondary data from BPS (Statistics Indonesia), the Ministry of Marine Affairs and Fisheries (KKP), and other relevant publications. The type of data in this study is panel data, consisting of cross-section data from 33 provinces in Indonesia and time series data from 2010 to 2020. The mathematical equation model of the research is as follows:

$$Y_{1it} = f(X_{1it}, X_{2it}) \dots \dots \dots (1)$$

$$Y_{2it} = f(Y_{1it}, X_{3it}) \dots \dots \dots (2)$$

$$Y_{3it} = f(Y_{1it}, Y_{2it}, X_{1it}, X_{2it}, X_{3it}) \dots \dots \dots (3)$$

Dimana:

- X1 = Number of fishing vessels/fleets
- X2 = Number of fishermen
- X3 = Fishermen’s Exchange Rate (NTN)
- Y1 = Number of capture fisheries households (RTP)
- Y2 = Level of fish consumption (AKI)
- Y3 = Production value

Based on the functional model, it is assumed to follow a non-linear function or the Cobb–Douglas function, so the regression equation is developed as follows:

$$Y_{1it} = \alpha_0 X_1^{\alpha_1} X_2^{\alpha_2} e^{\mu_1} \dots \dots \dots (4)$$

$$Y_{2it} = \beta_0 Y_{1it}^{\beta_1} e^{\beta_2 X_{3it} + \mu_2} \dots \dots \dots (5)$$

$$Y_{3it} = \lambda_0 Y_{1it}^{\lambda_1} Y_{2it}^{\lambda_2} X_{1it}^{\lambda_3} X_{2it}^{\lambda_4} e^{\lambda_5 X_{3it} + \mu_4} \dots \dots \dots (6)$$

The above equation can be rewritten as a structural equation:

$$\ln Y_{1it} = \ln \alpha_0 + \alpha_1 \ln X_{1it} + \alpha_2 \ln X_{2it} + \mu_1 \dots \dots \dots (7)$$

$$\ln Y_{2it} = \ln \beta_0 + \beta_1 \ln Y_{1it} + \beta_2 X_{3it} + \mu_2 \dots \dots \dots (8)$$

$$\ln Y_{3it} = \ln \lambda_0 + \lambda_1 \ln Y_{1it} + \lambda_2 \ln Y_{2it} + \lambda_3 \ln X_{1it} + \lambda_4 \ln X_{2it} + \lambda_5 X_{3it} + \mu_3 \dots \dots \dots (9)$$

Capture fisheries industry model (Model Y1)

$$\ln Y_{1it} = \ln \alpha_0 + \alpha_1 \ln X_{1it} + \alpha_2 \ln X_{2it} + \mu_1 \dots \dots \dots (10)$$

Consumption model (Model Y2)

$$\ln Y_{2it} = \pi_0 + \pi_1 \ln Y_{1it} + \pi_2 X_{3it} + \mu_4 \dots \dots \dots (11)$$

Production model (Model Y3)

$$\ln Y_{3it} = \delta_0 + \delta_1 \ln X_{1it} + \delta_2 \ln X_{2it} + \delta_3 X_{3it} + \mu_5 \dots \dots \dots (12)$$

According to Gujarati (1992) and Hariyanto (2005), in panel data, classical assumption tests are not required because it allows for a more complex study of behavior within the constructed model; the data is more informative, has greater variability, lower collinearity, more degrees of freedom, and is more efficient (Husna & Sofia, 2020)

4. Result and Discussion

To analyze the influence of determining factors on capture fisheries production in Indonesia, a simultaneous linear regression analysis is employed to estimate both direct and indirect effects. In this simultaneous regression model, the endogenous variables are Fisheries Household Units (RTP) (Y1), Fish Consumption Rate (AKI) (Y2), and the value of capture fisheries production (Y3). Meanwhile, the exogenous variables consist of the number of fishing fleets/vessels (X1), labor/fishermen (X2), and the Fishermen’s Exchange Rate (NTN) (X3).

Table 1. Estimation of Direct Effects

Exogenous Variable	Endogenous Variable	Coefficient	Standard Error	T-Statistic	Prob
Vessels (X1)	Y1	1,001	0,011	90,499	0,000*
Fishermen (X2)		0,016	0,016	1,016	0,310
NTN (X3)	Y2	-0,033	0,081	-0,403	0,687
RTP (Y1)		3,075	0,486	6,322	0,000*
Vessels (X1)	Y3	0,794	0,216	3,676	0,000*
Fishermen (X2)		0,737	0,062	11,957	0,000*
NTN (X3)		-0,013	0,005	-2,619	0,009*
RTP (Y1)		-0,952	0,212	-4,472	0,000*
AKI (Y2)		0,031	0,003	9,196	0,000*
C (Y1)	-0,300	R ² Y1**	0,978		
C (Y2)	20,666	R ² Y2**	0,100		
C (Y3)	13,253	R ² Y3**	0,482		
F Statistic	Y1	8105,7			
F Probability		0,000			
F Statistic	Y2	20,088			
F Probability		0,000			
F Statistic	Y3	66,334			
F Probability		0,000			
α	0,05*				

Source: Data Processed

Table 1 presents the direct effect estimates from the simultaneous linear regression. In model Y1, the constant of -0.300 indicates a decline in the fisheries sector when Fleet (X1) and Fishermen (X2) are absent. In model Y2, the constant of 20.666 suggests that fish consumption remains stable when the Fishermen’s Exchange Rate (NTN) (X3) and Fisheries Household Units (RTP) (Y1) do not increase. In model Y3, the constant of 13.253 implies that capture fishery production remains unchanged in the absence of increases in Fleet (X1), Fishermen (X2), NTN (X3), RTP (Y1), and Fish Consumption Rate (AKI) (Y2). Furthermore, the F-probability values confirm that all exogenous variables jointly have a significant effect on capture fishery production (Y3).

The R² for Y1 is 0.978, indicating that 97.8% of the variation in capture fisheries is explained by fleet size and the number of fishermen, with 2.2% attributed to other factors. For Y2, the R² of 0.100 shows that only 10% of the variation in fish consumption (AKI) is explained by RTP

and NTN, while 90% is driven by external factors. In Y3, the R^2 of 0.482 suggests that 48.2% of the variation in capture fishery production is explained by fleet size, fishermen, NTN, RTP, and AKI, with the remaining 51.8% influenced by variables outside the model.

Based on Table 1, the results indicate that the direct effect of fleet size on production is positive and significant (+ significant). An increase in fishing fleet size has a significant positive effect on capture fisheries production, highlighting fleet capacity as a key proxy for fishing effort. From a resource economics perspective, higher effort can raise catches in the short run when stocks are abundant, though this relationship may not remain linear over time.

Unregulated fleet expansion intensifies pressure on fish stocks, leading to declining catch per unit effort (CPUE) and diminishing returns to fishing effort. From a bioeconomic perspective, increases in fleet capacity must be aligned with management policies that account for the biological limits of fish resources.

This is related to the study Reiss et al (2009) Demersal fishing fleets physically disturb seabed habitats, with impacts varying by gear type, such as bottom versus pelagic trawls. "Fishing disturbance" reflects the frequency and intensity of fleet activity, increasing with larger fleet size and more frequent operations in the same area. This is also consistent with the study Pascoe et al (2012) Improving fleet efficiency can sustain or increase production with fewer vessels, supporting fisheries sustainability. The study assesses "technical efficiency," defined as a fleet's ability to maximize output from given inputs, where higher efficiency allows greater production with the same or fewer resources.

Vessel to RTP (Fisheries Household (+ Sig): he greater the number of fishing vessels, the higher the volume of catch that reaches Fisheries Household Units (RTP). This highlights the role of the fleet in supplying fish to RTP. This is consistent with the study Christopher Perks, (2011) Fisheries managers should use policies that shape productivity drivers, particularly fleet-related factors. Vessel-level productivity changes reflect fleet responses to measures like catch quotas, size limits, and gear regulations. This is also supported by Ellis & Allison (2001) The Sustainable Livelihoods Approach (SLA) frames fishing fleets as key physical capital for fisheries households, particularly small-scale fishers in low-income countries. Fleet availability and quality shape access to resources and income, influencing decisions on fishing effort, gear, and marketing. SLA highlights the link between fleets, livelihoods, and household strategies, informing policies that balance resource conservation with socio-economic welfare.

Fishermen to Production (+ sig): A larger fishing workforce significantly boosts production, highlighting labor as a key driver of fishing capacity. In resource economics terms, more fishermen increase total fishing effort in the system.

In many developing countries, fisheries operate as open access systems, where rising numbers of fishermen intensify competition and, without proper management, can lead to overexploitation and declining productivity.

In line with the findings of Coglán & Pascoe (2007) Investing in human capital enhances the efficiency and output of each fishing unit, allowing total production to be maintained or increased even with fewer vessels. Skilled fishers optimize methods within resource limits, supporting sustainable practices and making human capital a key driver of both productivity and fisheries efficiency.

Fishermen to RTP (fisheries households) (Not Sig): There is no significant direct relationship between the number of fishermen and the supply to Fisheries Household Units (RTP). This may be because the distribution of catches does not depend solely on the number of fishermen, but also on infrastructure, supply chains, and the roles of other actors. This phenomenon is

discussed by Fabinyi et al (2022) Coastal livelihoods are diversifying as fishing households seek alternative income sources amid sector challenges. Declining marine quality, reduced access, and lower catches limit fishers' earnings, while development pressures, such as land reclamation and industrial expansion, displace communities and damage small-scale fisheries infrastructure, further constraining household income from fishing.

NTN (Fishermen's Exchange Rate) to Production (- sig): A higher Fishermen's Exchange Rate (NTN) is found to be significantly negatively correlated with production. This can be understood through natural resource economics: when fish stocks decline and production falls, market prices for fish rise, which increases the relative income of fishers despite a decrease in catch volume.

In this context, a rise in the Fishermen's Exchange Rate (NTN) does not necessarily signal higher fisheries productivity; rather, it may reflect resource scarcity. As fish stocks decline from overexploitation, market prices increase, causing NTN to rise even while production decreases.

A study in China by YE, (1996) Higher production does not always lead to higher income. In China, constrained capture fisheries and growing aquaculture, alongside rising demand, can increase fish prices, boosting fishers' income even without output growth. In Northeast Norway, illegal fishing may provide short term gains but undermines long-term sustainability, highlighting the need for equitable management to secure stable incomes (Standal & Hersoug, 2023).

NTN (Fishermen's Exchange Rate) to AKI (Level of fish consumption) (Not Sig): There is no significant relationship between the Fishermen's Exchange Rate (NTN) and the Fish Consumption Rate (AKI). Fish consumption is more influenced by other factors such as absolute fish prices, household income, consumer preferences, and availability. This is stated by Motova & Zolubas (2010) In Lithuania, low fish consumption is linked to limited fishers' income, as 60–80% of catches are exported or used for industrial purposes like fishmeal. Industrial sales yield lower prices, reducing earnings, while diverting high quality fish from local markets limits domestic consumption and potential income from local sales.

RTP (Fisheries Household) to Production (-sig): The negative correlation between Fisheries Household Units (RTP) and production indicates that higher RTP activity is linked to lower output, as RTPs often serve as consumers or processors rather than producers. This may reflect a mismatch between resource production capacity and downstream value chain demand.

As fisheries sector units increase while resources remain limited, competition for raw materials intensifies, pressuring fish stocks and reducing overall productivity.

This phenomenon is described by Purcell & Pomeroy, (2015) The study underscores the need for fisheries policy reforms to sustain Small-Scale Fisheries (SSF) and their role in food and livelihoods. Rising coastal populations and declining fish stocks heighten resource pressure, threatening SSF viability and future production potential without intervention.

AKI (Fish Consumption Rate) to Production (+sig) : Higher Fish Consumption Rate (AKI) significantly boosts production, as strong domestic demand incentivizes increased fishing effort. However, without sustainable management, rising demand can overexploit fish stocks, highlighting the need for policies that align market demand with resource regeneration.

This is in line with the study by Merdekawati and Sofyan (2025), Fisheries productivity in Indonesia remains low due to weak institutions, limited technology, unfavorable policies for small-scale fishers, and fragmented infrastructure. Improving productivity requires human

resource investment, PIT policy reform, infrastructure development, and coordinated, sustainable stakeholder collaboration.

In fisheries, rising demand drives higher prices, incentivizing increased fishing effort through more labor, trips, and investment in equipment. This typically raises production, provided fish stocks are not critically overexploited. John O. Esin, Evans U.F, Affiong (2025) Effective demand can drive an increase in production, which in turn contributes to economic growth. In their study, the authors analyze trends in fish demand and domestic production in Nigeria. Strong fish demand drives higher production, supporting GDP growth, with capture fisheries growing at 4.19% annually. In Turkey, demand is a key motivator, highlighting its role as a primary economic driver of fisheries output (Eyüboğlu & Akmermer, 2023). In Indonesia, fish demand indirectly influences production, driven by fish prices, substitute goods, and consumer income. Rising demand from these factors pressures capture fisheries to increase output to meet market needs (Firmansyah et al., 2020).

RTP (Fisheries Household) to AKI (Fish Consumption Rate) (+Sig): The higher the level of RTP activity (in terms of harvesting, processing, and distribution), the higher the Fish Consumption Rate (AKI). This highlights the important role of Fisheries Household Units (RTP) in providing fishery products that are ready for consumption. Junianto et al (2023) Capture fisheries households underpin the sector, supporting SMEs and overall fish consumption. By aligning products and marketing with consumer preferences, these households and SMEs enhance fish availability and appeal, boosting consumption (Tenji Pem Bhutia, 2019).

In Indonesia, increases in fishing vessels and labor significantly raise fisheries output, indicating that expanding capacity still boosts production. However, this relationship may not remain linear due to the Law of Diminishing Returns on finite marine resources.

The Fishermen’s Exchange Rate (NTN) is negatively correlated with production, indicating that higher income or resource scarcity can reduce fishing effort and total output. Rising NTN may reflect higher prices or declining fish stocks, meaning lower production results from limited resources rather than reduced fisher welfare.

Fish Consumption Rate (AKI) positively drives production, reflecting consumer demand, while Fishing Households (RTP) negatively correlate with output, as they focus on post harvest activities. RTP activity rises when raw material is scarce, emphasizing value addition and efficiency rather than primary production.

Conversely, RTP shows a significant positive correlation with AKI, underscoring the important role of RTP in providing ready to consume fishery products and driving consumption levels.

Table 2. Indirect Influence of Fish Consumption Rate Through RTP

Exogenous Variable	Endogenous Variable	Coefficient	Standard Error	T Statistik	prob
Vessels (X1)	Y1	3,078	0,486	6,333	0,000*
Fishermen (X2)		0,049	0,486	1,007	0,314
α	0,05*				

Source: Data Processed

Table 2 shows that fleet size positively affects AKI through RTP, emphasizing RTP’s role in linking production to consumption. Efficient RTP coordination shapes product quality, pricing, and availability across the supply chain. Fisheries research in the Mediterranean Sea of Egypt by Abdelaziz et al., (2024) RTP and fisheries MSMEs often operate at various stages of this value chain. They can be involved in small-scale processing of catches (adding value),

act as intermediary traders (connecting fishermen to the market), or even sell directly to consumers.

The non significant indirect effect of fishermen on AKI via RTP indicates that changes in fisherman numbers do not directly affect consumption. RTP's processing and distribution are driven mainly by efficiency, capacity, networks, and technology, with fisherman supply acting only as a constraint on throughput. Market segmentation and product specialization weaken the link between fisherman numbers and RTP activities. Community consumption is inelastic to short term supply changes, and RTP operations are shaped more by technology, regulations, market trends, and infrastructure than by fisherman numbers, limiting the impact of increased supply on consumption.

Oudwater et al (2002) Globalization and market liberalization heighten competition for RTP and MSMEs, as foreign products challenge pricing and quality. Stricter global standards in processing, packaging, and certification can strain small-scale operators. As a result, RTP and MSMEs risk losing access to export and high quality domestic markets. Globalization shifts consumer preferences toward imported or processed products, and failure to adapt can reduce their market appeal.

Table 3. Indirect Influence of Vesse , Fishermen, and NTN on Production Value Through RTP and AKI

Exogenous Variable	Endogenous Variable	Coefficient	Standard Error	T-Statistic	prob
Vessel (X1)	Y3 Through Y1	-0,952	0,027	-4,609	0,000*
Fisherman (X2)		-0,015	0,015	-0,996	0,319
NTN (X3)	Y3 Through Y2	-0,001	0,002	-0,405	0,686
Vessel (X1)	Y3 Throughi Y1 dan Y2	2,444	0,754	3,240	0,001*
Fisherman (X2)		0,036	0,040	0,973	0,331
α		0,05*			

Source: Data Processed

Table 3 shows that the indirect effect of fleet size on production via RTP is negative, reflecting inefficiencies. When fleet catches exceed RTP's processing and storage capacity, fish quality and marketable volume decline. Without improvements in RTP efficiency, larger fleets can cause oversupply and lower overall productivity. Excess fleet production can depress fish prices, reduce fisher incentives, and limit market absorption. Mismatches with RTP specialization and heightened competition for raw materials can further lower processing efficiency and overall output.

The negative relationship underscores the need to consider RTP capacity and efficiency when expanding fleets. Policies that increase fleet size without improving RTP infrastructure risk reducing overall fisheries production. Research in Peru by De la Puente et al (2020) Since 2006, fishing effort in Peru has risen faster than catches, lowering indicators like catch per unit effort, revenue per unit effort, and fisher income. Despite more vessels and gear, productivity and earnings especially for RTP actors have declined, highlighting unsustainable and uneconomical growth. Some RTP sustain incomes through non-selective or illegal fishing, showing strategic responses to resource pressure. However, this mediation can reduce overall production, as declining catch per unit effort in RTP may stall or lower national fisheries output, especially where small-scale fisheries dominate.

The positive indirect effect of fleet size on production via RTP and AKI shows that increased fishing capacity can boost output when RTP's processing and distribution are combined with strong consumer demand, offsetting RTP's negative direct effect.

An increase in fleet numbers can temporarily overload RTP's processing capacity, causing inefficiencies and lower recorded production, which may explain RTP's negative direct effect. Conversely, a high Fish Consumption Rate (AKI) reflects strong market demand, incentivizing the supply chain, including RTP, to boost output.

A high Fish Consumption Rate (AKI) signals strong market demand, motivating RTP to improve processing efficiency, diversify products, and expand distribution. Sustained demand encourages investment in capacity, storage, and logistics, ultimately increasing overall production. Expanded RTP capacity allows larger fleet catches to be processed into market-ready products. Although fleet growth may initially strain RTP, strong consumer demand (AKI) drives efficiency, capacity expansion, and wider distribution, ultimately turning initial RTP constraints into higher overall fisheries production.

This highlights the importance of integrating supply (fleets and RTP) and demand (AKI) factors in fisheries production. Effective policies should expand fishing capacity, strengthen processing and distribution, and sustain consumer demand.

Saltykov & Fisenko (2023) In Russia, small-scale capture fisheries are often household-based, so fleet expansion boosts RTP participation by creating employment and business opportunities. Fish consumption, shaped by price and availability, further links production to increased household involvement in fisheries. Increased RTP activity expands domestic supply, potentially lowering local prices and stimulating Fish Consumption Rates (AKI). Higher AKI then incentivizes fishermen and fisheries firms to raise catches or production, enhancing overall fisheries output.

The non-significant indirect effect of fisherman numbers on production whether via RTP alone or through RTP and AKI indicates that small-scale changes in fishermen do not meaningfully alter total raw material supply to RTP, which sources inputs from multiple channels.

An increase in fishermen does not necessarily stabilize RTP supply, as many target species may not align with RTP processing needs. RTP mitigate this by sourcing from diverse channels including Fish Auction Sites (TPI) and traders reducing dependence on local fisherman fluctuations. Geographic gaps between fishermen and RTP sites make logistics critical, so local increases in fishermen do not directly boost RTP output elsewhere. This nonsignificant mediation indicates that enhancing fisheries production and consumption depends more on supply chain efficiency, RTP operations, and consumer demand than merely on fisherman numbers.

Park et al (2012) Central Korean fisheries face domestic and international pressures from declining catches, rising fuel costs, and stronger global trade and regulatory influences. Strategies focusing solely on increasing fisherman numbers are unlikely to effectively enhance production or consumption. RTP efficiency depends on training, technology, and capital, while AKI growth relies on product diversity, price stability, and consumer awareness. Increasing fisherman numbers alone does not guarantee higher production or translate into greater national fish consumption.

The non significant indirect effect of NTN on fisheries production via AKI indicates that fishermen's relative earnings do not reliably drive community fish consumption. Consumption is primarily shaped by absolute market prices and overall purchasing power, making AKI largely insensitive to changes in NTN. Production may not increase immediately with higher AKI due to fleet limits, regulations, or resource constraints. This nonsignificant mediation indicates that improving fishermen's welfare (NTN) alone does not translate into

higher production, as consumption and production responses largely operate independently of NTN.

Policies targeting production via consumption cannot depend solely on NTN, as AKI is driven by household factors, local preferences, and market constraints that are largely independent of fishermen's earnings. Regional market fragmentation driven by income, occupation, and species preferences means national NTN changes do not reliably affect local AKI. Effective strategies require understanding local consumption drivers and addressing community level constraints.

The indirect effect of NTN on fisheries production via AKI is nonsignificant, as fish consumption is shaped by prices, availability, preferences, habits, and household conditions. NTN influences consumption only indirectly, and higher earnings do not guarantee increased supply due to production and environmental constraints. Thus, enhancing fishermen's welfare alone cannot substantially raise consumption or production without addressing market and consumption barriers (N. Al-Mazrooei, G.V. Chomo (2003), Devi et al (2023), Chaudhary et al (2023), Can et al., (2015)).

Indonesia's marine capture fisheries depend on fleets, fishermen, and NTN, while fishing households and consumption highlight the need for integrated management. Policies targeting capacity alone risk inefficiency; sustainable productivity requires coordinated action across production, supply chains, RTP, and consumer demand.

5. Conclusion and Suggestion

This study highlights that marine capture fisheries production in Indonesia is driven by the interplay of fishing inputs, fishermen's economic conditions, and market demand. Although expanding fleets and labor enhances production, such growth is inherently limited by the regenerative capacity of fish stocks, underscoring the need for sustainable management.

The negative link between the Fishermen's Exchange Rate (NTN) and production shows that higher fishermen welfare does not always coincide with increased catch. Scarcity-driven price rises can elevate NTN even as production falls, highlighting that fisheries output depends on both economic factors and the regenerative limits of fish resources.

Fishing Households (RTP) mediate the effects of production capacity on output, emphasizing the value chain's role. Interactions with fish consumption (AKI) show that domestic demand can amplify or dampen production impacts, yet rising demand without proper resource management may intensify pressure on fish stocks.

Optimizing capture fisheries requires both increased production capacity and sustainable resource management. Policies should combine fishing effort regulation, value chain efficiency, fishing household capacity building, and demand management aligned with fish stock regeneration to ensure economic gains while safeguarding long-term resource sustainability and fishermen's welfare.

Although this study does not fully address factors like infrastructure, supply chains, consumer preferences, policy, or ecosystem issues, optimizing capture fisheries requires sustainable governance, efficient and value added supply chains, strengthened fishermen capacity and welfare, and balanced stimulation of consumer demand.

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