International Journal of Economics Development Research, Volume 5(4), 2024 pp. 3016-3037

Linking Fishery to Deforestation Case Study in Indonesia

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Abstract:

Indonesia possesses abundant natural resources and biodiversity, especially within its fisheries industry. Despite this abundance, the nation faces challenges due to population growth and globalization, often associated with deforestation. A report from the FAO outlined various concerns regarding the correlation between forest area impacts and fish catches, considering a nursery area perspective. However, from a socio-economic standpoint, population growth consistently leads to heightened resource utilization. An inferential analysis study involving forest area, GDP, and fish catch biomass from 1990 to 2020 indicated that both forest area and GDP have a significant influence on fish catch biomass. The study revealed a consistent trend: fish catches tended to increase in the following year, but fish catch biomass showed a tendency to decrease five years later. The findings show a 99.9% coefficient of determination, suggesting a highly significant relationship. This research emphasizes the complex linkages among economic progress, forest depletion, and fishing activities, underscoring the essential role of sustainable resource management in addressing changes in both society and the environment.

***Keywords**: Fish catching, Gross domestic product, Forest, Regression, Autoregressive Model.*

Submitted: 3 May 2024, Accepted, 12 July 2024, Published: 9 October 2024

1. Introduction

Indonesia possesses a wide range of natural resources, such as mineral deposits, energy sources, agricultural products, and tourist attractions. The fisheries sector is a significant source of abundance in Indonesia. However, despite the plentiful and diverse nature of Indonesia's fisheries resources, this sector encounters various challenges and concerns regarding the sustainable management of natural resources (Kadarusman, 2019). The growing impact of globalization and Indonesia's increasing population are key factors contributing to the strain on the nation's natural resources (Khoirunisa, 2023; Widyaningrum, 2020).

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The process of globalization takes place on a global scale. and involves the weakening of boundaries in political, economic, cultural, and social domains. In an increasingly globalized world, the activities in one country have significant effects on other countries politically, economically, socially, and culturally. Globalization results in the spread of Western capitalism by influential international groups, leading to the breakdown of the socialist principles that underlie Indonesia's economic system as well as national and populist ideologies. This phenomenon gives rise to a modern type of colonialism referred to as neocolonialism. Neocolonialism was described by President Soekarno as Indonesia being reduced to a supplier of inexpensive raw materials for the benefit of industries in developed countries (Sulaiman, 2019). In the context of Indonesia's economy, globalization means that demand originates from both domestic and foreign markets.

The growth of a country's population contributes to the improved productivity of extractive sectors like agriculture, fishing, and forestry to satisfy the demand for clothing, food, and housing. For instance, Indonesia is recognized for its high rice consumption. Based on data from the World Bank, Indonesia had a population of 247.1 million individuals in 2011, which rose by 9% to reach 269.5 million in 2019 (TWB, 2018). Throughout this period, the national rice consumption also experienced a 5% increase, from 27.3 million tons in 2011 to 28.7 million tons in 2019 (Badan Pusat Statistik, 2019).

The FAO has published a paper that explores the connection between forests and wild fish production. According to the paper, forests serve as important nursery areas for fish to mature and breed. Despite this, the report acknowledges that there are difficulties in fully understanding the relationship between these two factors (Saenger, 2013).

In developing nations like Indonesia, forests often undergo deforestation to fulfill essential requirements. Simultaneously, the demand for fish catches to satisfy market needs adds complexity to understanding the correlation between these two factors. The use of trawl nets is further aggravating this situation by boosting fish-catching efficiency. Therefore, analysis using regression techniques tends to yield findings that conflict with the nursery area concept (Saenger, 2013).

The focus of research often lies on the nursery area concept, posing a challenge in clarifying the link between forests and fish production. This difficulty arises from the concept's lack of universal applicability. While some fish species inhabit these environments, others do not. Additionally, certain fish species only utilize the forest during their early life stages and then migrate elsewhere in their adulthood. Furthermore, there are species that are not reliant on forest cover and can adapt to changes in their habitat (Saenger, 2013).

Based on the current issues and areas needing further research, it is essential to conduct a study to elucidate the connection between forests and fisheries from a fresh angle. This investigation will encompass factors like forest coverage and GDP, which can serve as indicators of the influence of economic globalization and population expansion on Indonesia's domestic fish output. The anticipated outcome of this study is to make a meaningful contribution to the development of sustainable fisheries management policies.

2. Theoretical Background

A. Gross Domestic Product

Gross domestic product is one of the indicators that becomes a benchmark for evaluating the condition of Indonesia’s economy (Yuliati, 2021). Gross domestic product becomes the reflection of the market value of all commodities and services produced inside the boundary of a country. Gross domestic product is used to measure the market value of all available commodities and services, including capital goods, household consumptions, and investments, until the export and import activity of a country (Syadza, 2021).Besides, GDP is also used to measure the economic activities inside the border of a country, which covers the overall domestic and international economic activities of the population of a country (Waroy, 2014) .This section explains the correlation between GDP and catches of fish, based on a theory of macroeconomic state income that is household consumption, investment, government expenditures, export, import, or international trade.

1. Public Consumptions of Fishery

The consumption of food by the people of Indonesia is so varied depending on the culture, geographic conditions, economic state, and the availability of foodstuffs in respective areas (Indrawasih, 2016). As a country with massive people and a wide area, food security is one of the most important aspects of supporting the development of Indonesia’s economic system (Ariani, 2014).

A country with a geography having a significant coastline and inland waters like Indonesia tends to have a habit of consuming fish (Guenard, 2020). As the second largest archipelagic country with a coastline of 99,083 kilometers, Indonesia reached a fishery production of 21,834,105.4 tons in 2020 with a per capita consumption of 54.56 kgs in 2020

(KKP, 2020). According to The Presidential Advisory Council, the potential of Indonesia’s fishery production could reach 67 million tons annually, consisting of 10.2 million tons of caught fish and 56.8 million tons of cultivated fish. Compared to the great potential of Indonesia's fishery, the consumption of fish by its people is still considered low (Wantimpres, 2017).

There was research comparing the correlation between income and fish demand globally and the demand for (land animal) meat in 2015. The result showed that there was a weak correlation between the increase in income and global fish consumption demand compared to the demand for land animal meat, such as chicken, beef, mutton, etc. This issue shows that the world population prefers land animal meat
(Figure 1).

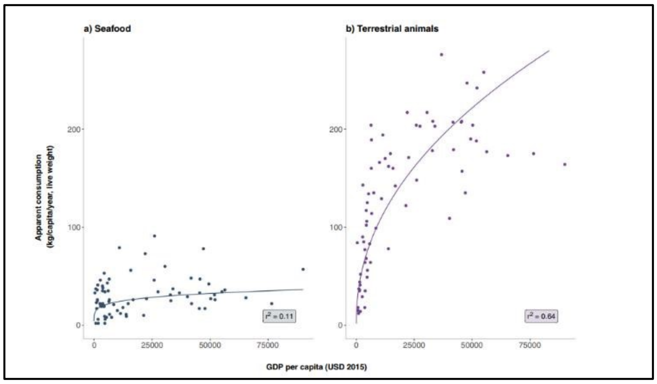


Figure 1 The correlation of household income to fish and meat consumption globally Source: Naylor, 2021

The case in Indonesia is different. Indonesians tend to consume fish when their income rises (Figure 2.1.2). (Figure 2) Quoted from the website of Indonesia.go.id, Indonesia's meat consumption is still far below the average. The report of the Central Bureau of Statistics states that the consumption of beef globally in 2022 is about 6.3 kg/cap while the consumption of beef and water buffalo meat in Indonesia is only about 2.5 kg/cap. The consumption of chicken meat globally is about 14.9 kg/cap in 2021 while in Indonesia, it is only 8.1 kg/cap. The consumption of other kinds of meat such as mutton, lamb, etc. is also still below the average (Dwitri, 2023)

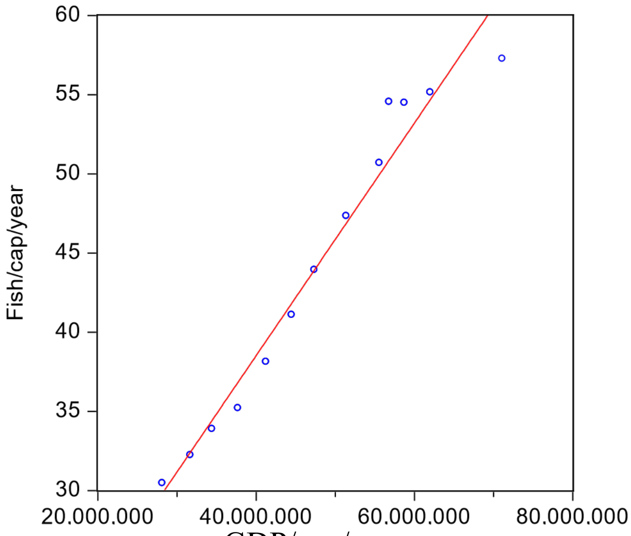


Figure 2 The Correlation between Household Income and the Consumption of Fish in Indonesia in the period of 2010 – 2022
Source: TWB, 2019

The phenomenon mentioned above is parallel with Keynesian macro-economic theory concerning consumption which states that the increase of disposable income will raise consumption. The total consumption is impossible to be zero because basically, households need consumption (*autonomous consumption*). That is why when there is no income, households will use their saving for consumption (Chandra, 2016). Consumption in households will raise the income of other economic agents. In this case, the rise of disposable income will raise the consumption of fish, then raise fish catching, and eventually raise the income of fishermen.

2. Investment in Fishery

Fishing in Indonesia has been conducted since the ancient era. Before the 19th Century, fishing was conducted merely to fulfill daily (subsistence) needs for food of coastal and surrounding people. In the 19th Century, the was a huge rise in fishing due to urbanization. Following World War II, the rise of fishing was triggered by the operation of fishery industries, characterized by the modernization of fish-catching equipment such as seine, trawl, and nets (Oktariza, 2014). In 2010, fishing tended to be stagnant because of switching to fish cultivation Figure 3

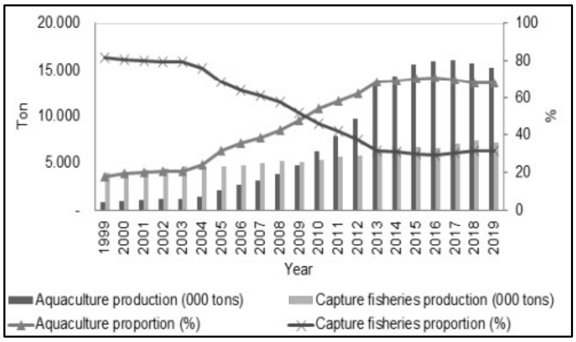


Figure 3 The comparison of fishing production with aqua-culture, 1999 – 2019
Soure: Aryudiawan, 2022

The mechanization and modernization of fishing began in 1969 on Sumatera Island using seine. Fishing modernization was stimulated by Japanese company's investment. That made an increase in fishing. However, following 1970 to 1971, there was exploitation of fishing on that island, resulting in a decrease in fishing. The fishing fleet then moved to the north of Java and south of Papua Island. Shortly after, from 1973 until 1976, fishing drastically decreased and at the end of the 1970s, there was no more new area that could be exploited. The decrease in fishing created a conflict between traditional fishermen and seine fishermen, forcing the authorities to ban the using of seine since the 1980s in some areas (Morgan, 2006).

3. Governments Expenditures and Policies Concerning Fishery Industry in Indonesia

Government assistance in fishery industries in 2018 was about 2.06 trillion rupiahs and increased to 11.01 trillion rupiahs in 2019. The majority of the fund (50%) was allocated to the operation of fishing by supplying fuel to fishermen. The rest was for subsidies such as fishery infrastructure, income assistance, marketing, and fishery management (Suharsono, 2021).

According to the available research, subsidies to fishermen are the main factor of overcapacity which makes fishermen catch more fish than it supposed to (Sitanggang, 2019; Suharsono, 2021). Although there is still no research that could directly prove it until now (Soeparna, 2024), the suspicion of subsidy as the main factor of overcapacity has a strong basis. There are two bases of overcapacity, they are natural resources struggling among fishermen which results in catching more fish than it supposed to be (Trenggono, 2023), and some regulations that indirectly stimulate overinvestment (Salsabila, 2023). Public subsidy which initially had the goal of welfaring fishermen by reducing personal costs and increasing income turned out to indirectly stimulate the catching of fish more than the market's demand (Stone, 1997; Yusri, 2020)The research on the biomass of globally caught fish in 2003 shows a decrease in the biomass of global predator fish of 80% since 1950, the pre-industrial era, until the 1990s (Myers, 2003).

4. The Role of International Commerce in Fishery Industry in Indonesia

International commerce, including export and import, plays an important role in the fishery industry in Indonesia. Indonesia is one of the main exporters of fishery products in the world (Paramita, 2011). The main export commodities are fish, shrimp, squid, lobster, and fish-based products such as salted fish and fish crackers (Adam, 2018).

The increasing global transactions of Indonesia's fishery products become one of the main factors of the increase in fishery products export. The main export market of Indonesia includes countries in Asia, Europe, and America. Some of the main destination countries for exporting

Indonesia's fishery products are The United States, Japan, China, and the European Union. Initially, in 1999, Japan was the main target of Indonesia's fishery products export. However, in 2019, there was a switch of market to China and The United States which made the Japanese market condition tend to be stagnant and there was high competition against Vietnam and Thailand (Aryudiawan, 2022).

Even though Indonesia has become a fishery products exporter, it also imports certain commodities (Kusdiantoro, 2019).The reasons beyond this may be variative, including meeting the high demand of consumers, obtaining some variety of certain products, or overcoming the inability to domestic products. The government has an important role in managing fishery international trading (Ratih, 2012). One of the commodities that demand fishery products import is mackerel fish which is often utilized in producing pindang fish (Arthatiani, 2020).

The effort to increase the continuity of fishery production, such as continuous fishery certification, could influence the access to international market. Fishery products themselves could contribute significantly to the economic growth of Indonesia and provide many jobs in this sector (Boediono, 2020). The high dependence on exports which raises the risks of the world's fluctuation of commodity price, global demand, as well as international commerce could create tension on fishery resources if they are not well managed. That is why, there needs to be a balance to avoid overfishing (Zebua, 2002).

B. Forest Width and Fishery Sector Connectivity

Review "The future of hyperdiverse tropical ecosystems" (Barlow, 2018)

Tropical areas hold a significant amount of the Earth's biodiversity, but they are undergoing rapid transformations due to environmental, socio-economic, and demographic changes. These transformations are frequently impacted by industrialized nations situated distant from the tropics.

Tropical regions experience the highest levels of land-use change and degradation, with deforestation in tropical areas surpassing 5 million hectares annually since the 1990s. This situation is exacerbated by the expansion of major infrastructure projects such as dams, as well as the growing demand for agricultural goods, biofuels, timber, fuelwood, and other natural resources, leading to significant impacts on ecosystems. Despite efforts to mitigate these issues, dams create nearly impassable obstacles for fish, while deforestation leads to the displacement of unique forest species by a small set of common open-water fish species.

The effects of changing how land is used also impact the surrounding areas by creating isolation and edge effects, as well as by causing human-induced disturbances and climate change. The edge effect leads to a decrease in the number of endangered vertebrates up to 200–400 meters into tropical forests. Land-use change also introduces pollution that poses a threat to tropical ecosystems. Sediment and nutrients entering the water as a result of land-use changes contribute to the decline of freshwater, coastal, and coral reef biodiversity. The increased use of pesticides reflects a rapid increase in agricultural, plantation, and forestry practices driven by significant pest threats. Overexploitation is also observed in tropical regions. For instance, fishing in tropical areas has led to a 75% reduction in biomass in one-third of coral reef areas and the extinction of several economically valuable tree species.

Deforestation and land conversion are contributing factors to global warming. Global warming impacts different regions differently, with tropical areas being the first to feel its effects. The rise in temperature is prompting fish species to move to higher latitudes or deeper waters. However, the movement of fish species in freshwater areas is uncertain due to various obstacles. If migration does not occur, fish species will have to decide between adapting to survive or facing extinction.

The presence of abundant natural resources in tropical regions is linked to advancements in demographics and economics. The population in tropical areas is growing at a faster rate compared to other regions, and it is estimated that approximately half of the world's population will be residing in tropical regions by 2050. The increasing population in the tropics is accompanied by a rise in GDP, which is correlated with the expansion of extractive industries and agriculture. This trend suggests that enhanced social performance is consistently linked to increased utilization of natural resources. The growing tropical populations will result in heightened demand for timber, water, food, energy, and land, leading to significant environmental degradation. Furthermore, globalization is also contributing to heightened pressure on natural resources. Market integration is one factor contributing to meeting the demands of foreign/export markets.

3. Methodology

The study's population encompasses Indonesia's fish catch, GDP, and forest area from 1990 to 2020. Secondary data for the study was sourced from the data-worldbank website and relevant journals accessible via Google Scholar. Subsequently, the data was organized to fit the processing format of the Eviews application. Once structured, the data was inputted into Eviews for the management and development of research variable estimation models. The findings were then interpreted based on existing published research and evidence.

In this study, the research employs the inferential analysis technique. This method involves using observable data to make educated guesses about unobservable phenomena (Cambridge University, 2019). The analysis utilizes the ordinary least squares (OLS) method, which aims to minimize the sum of squared residuals or errors (ASHP, 2006), and incorporates an autoregressive model to address the issue of autocorrelation. The regression model estimation involves two independent variables - forest area and GDP, and one dependent variable - catch fish biomass.

The autoregressive model predicts an event by considering previous period events or lags (LaBarr, 2019).

$$Y_t = \omega + \phi Y_{t-1} + e_t$$

$$Y_{t-1} = \omega + \phi Y_{t-2} + e_{t-1}$$

$$Y_t = \omega + \phi (\omega + \phi Y_{t-2} + e_{t-1}) + e_t \quad Y_t = \omega^* + \phi^2 Y_{t-2} + \phi e_{t-1} + e_t$$

ω = intercept
ϕ = coefficient
Y_{t-1} = lagged dependen variabel.
e_t = error

The value of Y_{t-1} is affected by the value of Y_{t-2}, which in turn is affected by the value of Y_{t-3}, and so on, until the first observation result (Y1). The mathematical model presented indicates that previous events have a diminishing impact on current events if $|\phi| < 1$, consistent with the concept of stationarity, where the influence of past variables persists but diminishes over time. As a result, the autoregressive model is also known as the long-term memory model (LaBarr, 2019).

$$Y_t = \omega + \phi(\omega + \phi Y_{t-2} + e_{t-1}) + e_t$$

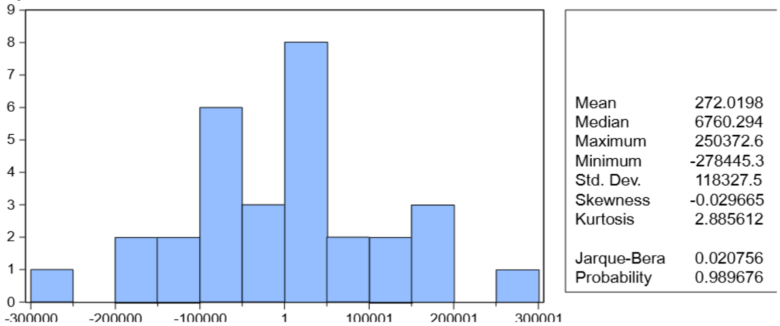
$$Yt = \omega^* + \phi2\ Yt\text{-}2 + \phi\ e\ t\text{-}1 + e\ t$$

$$Yt = \omega^* + \phi3\ Yt\text{-}3 + \phi2\ e\ t\text{-}2 + \phi\ e\ t\text{-}1 + e\ t$$

$$Yt = \frac{\omega}{1-\phi} + \phi t\ Y1 + \phi t\text{-}1\ e2 + \phi\ t\text{-}2\ e3 + \ldots + e\ t$$

4. Empirical Findings/Result and Discussion

Normality Test



Source: Result of data processing

Figure 4. Normality Test

Multi Co-linearity Test

Table 1. Multi Co-linierity Test

Variance Inflation Factors
Date: 01/22/24 Time: 16:18
Sample: 1990 2020
Included observations: 30

	Coefficient	Uncentered	Centered
Variabel	Variance	VIF	VIF
C	1.29E+12	2523.167	NA
FOREST(-1)	3.74E+08	2102.719	5.951597
GDP(-1)	3.64E-14	30.79556	6.606374
AR(1)	0.025734	1.731320	1.633788
AR(5)	0.024923	1.405910	1.370848
SIGMASQ	1.94E+19	1.495350	1.495000

Source: Result of data processing

Heteroskedasticity Test

Table 2. Heteroscedasicity Test

Heteroskedasticity Test: White

F-statistic	7.70E+19	Prob. F(27,2)	0.0000
Obs*R-squared	30.00000	Prob. Chi-Square(27)	0.3142
Scaled explained SS	18.09923	Prob. Chi-Square(27)	0.9005

Source: Result of data processing

Correlation Test

Table 3. Correlation Test

Covariance Analysis: Ordinary
Date: 04/21/24 Time: 12:34
Sample: 1991 2020
Included observations: 30
Balanced sample (listwise missing value deletion)

Correlation Probability	FISH	FOREST1	GDP1
FISH	1.000000 -----		
FOREST1	-0.911952 0.0000	1.000000 -----	
GDP1	0.946144 0.0000	-0.760413 0.0000	1.000000 -----

Source: Result of data processing

Cointegration Test

Table 4. Cointegration Test

Date: 10/07/24 Time: 08:29
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: FISH FOREST GDP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.438087	35.69847	42.91525	0.2175
At most 1	0.320694	18.98261	25.87211	0.2818
At most 2	0.235008	7.768797	12.51798	0.2711

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.438087	16.71586	25.82321	0.4819
At most 1	0.320694	11.21382	19.38704	0.4916
At most 2	0.235008	7.768797	12.51798	0.2711

Source: Result of data processing
Max-eigenvalue test indicates no cointegration at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values

Estimated Result

Table 5. Estimated Result

Dependent Variabel: FISH
Method: ARMA Maximum Likelihood (OPG - BHHH)
Sample: 1991 2020
Included observations: 30
Convergence achieved after 15 iterations
Coefficient covariance computed using outer product of gradients

Variabel	Coefficient	Std. Error	t-Statistic	Prob.
C	10874338	1135751.	9.574577	0.0000
FOREST(-1)	-124969.1	19338.40	-6.462224	0.0000
GDP(-1)	2.16E-06	1.91E-07	11.31349	0.0000
AR(1)	0.542083	0.160418	3.379196	0.0025
AR(5)	-0.486372	0.157870	-3.080844	0.0051
SIGMASQ	1.35E+10	4.40E+09	3.075060	0.0052

R-squared	0.991951	Mean depen dent var	5001068.
Adjusted R-squared	0.990274	S.D. dependent var	1318891.
S.E. of regression	130071.0	Akaike info criterion	26.66317
Sum squared resid	4.06E+11	Schwarz criterion	26.94341
Log likelihood	-393.9476	Hannan-Quinn criter.	26.75283
F-statistic	591.5274	Durbin-Watson stat	1.744351
Prob(F-statistic)	0.000000		

Source: Result of data processing

It is important to test the validity and reliability of independent variables before testing the hypothesis. The bar chart in the normality test shows the Jarque-Bera probability of 0.98 and has a normal distribution. This indicates that the data used could give accurate and valid estimations.

The result of the multi-collinearity test shows the VIF of each independent variable is below 10, which means that independent variables are not correlated. However, VIF of more than 5 becomes the indicator of high multicollinearity. Multi-collinearity does not influent the accuracy of models

in estimating an event but could make the estimation unreliable. That is because the change in one independent coefficient will change the other independent coefficients (Bhandari, 2024))
.
The result of the heteroskedasticity test shows the probability Obs*R-Square 31% (> 5%). This result indicates that the variance of standard error is constant. If a model is heteroskedasticity, the error standard in the future will become more or less which makes it inefficient (Anita, 2021)

The result of the correlation test shows that the probability of correlation between variables is dependent as well as independent. P-value = 0.00 for each variable shows that all variables have a significant correlation. Then above the P-value is the degree of correlation coefficient. The correlation coefficient shows the level of correlation strength between variables. The following is the guidance on the degree of correlation (Sukron, 2023).

Table 6. Correlation Degree

Correlation Value	Correlation Degree
0,00 - 0,20	Very Weak
0,20 – 0,40	Weak
0,40 – 0,60	Medium / Fair
0,60 – 0,80	Strong
0,80 – 1,00	Very strong

Source: Sukron, 2023

The result of the correlation test shows that caught fish has a strong negative correlation with the width of the forest and has a strong positive correlation with GDP. The correlation of forest width with GDP is strongly negative.

The cointegration test used is the Johansen cointegration test with 5% ∝. The result of this test is used to find out whether the variable used in regression modeling has a long-term correlation or not (anonymous, 2016).

The result of estimation shows that the equation with a non-linear model is spared from the autocorrelation problem, proved by Durbin Watson value (1.744351) > Du (1.510) > Dl (0.941), (∝< 1%). AR in the result of estimation shows the trend in fishing which means that the result of fish catching is not independent of different periods.

The *T-value* probability of forest and GDP variables is below 1%. This indicates that each GDP and forest has a significant influence independently on the result of fishing. The T-value of autoregressive variables also has a significant probability independently. The result of estimation shows a significant F statistic of < 1%, which means that each independent variable and trend have a simultaneous influence.

The coefficient in the result of estimation shows each independent variable's degree of influence on fish catching variable. The variable forest and AR(5) show a negative correlation while GDP and AR(1) show a positive correlation. The result of the coefficient indicates an enhancement of GDP and the fishing trend in the previous year will increase the fishing this year., while the enhancement of the variable forest and variable fishing 5 years before will decrease the present fishing. The result of the estimation has fulfilled the condition of BLUE. With the following equation:

$$FSH_t = 10874338 - 124969.1\ FRST_{t-1} + 2.16\ GDP_{t-1} + 0.542083\ AR(1) - 0.486372\ AR(5)$$

$$+\mathbf{1.35}\ \boldsymbol{X}\ \boldsymbol{\epsilon}$$

This equation is 99% able to explain the quantity of caught fish, while the 1% is explained by other variables with the error tolerance of 1%. The variable GDP matches the theoretical basis, each raise of 1 unit USD will raise 2.16 units of caught fish. 1 unit of forest width reduces 124969 units of caught fish. AR(1) indicates a dependency on period *t*-1, each 1 unit raise of caught fish in period *t*-1 will increase 0.542 metric tons of caught fish in period *t*. AR(5), each unit of raise in caught fish in 5 years will make a 0.486 decrease of caught fish in period *t*.

The Impact of Forest Factors on The Biomass of Fish Catch

The more forest area there is in the previous year, the less fish biomass is caught in the following year. According to current findings, forests have an impact on a socioeconomic occurrence. This is evident from the presence of multicollinearity between forest and GDP variables and the individual as well as combined significance of each variable in influencing the biomass of Indonesian fish catches. The modeling outcomes validate the study carried out by Barlow (**Section IIB**) .The study examines tropical ecosystems affected by deforestation, overfishing, and climate changes. This calamity is a result of socioeconomic occurrences such as pressure from an increasingly globalized world, rising human population, and insufficient governance and government responses to ongoing issues. The issues identified by FAO in the discussion on the connection between forests and marine fish catches from a nursery area viewpoint are also clarified by these results.

How GDP Affects the Biomass of Fish Catch.
The following passage outlines the elements of GDP and their influence on fish catches. In modeling, GDP serves as an indicator of socio-economic occurrences in Indonesia's capture fisheries. Unlike the forest area variable, GDP lacks the capability to elucidate the impact of weather fluctuations on fish distribution and the decline of certain fish species due to the disruption of freshwater ecosystems caused by deforestation.

The results of the modeling indicate a positive correlation, suggesting that the rise in GDP in the previous year had a direct impact on the increase in fish catches. According to existing literature, the surge in fishing activity in Indonesia can be attributed to the growing demand in both domestic and foreign markets, driven by the expanding population. This surge has captured the interest of investors looking to enhance the Indonesian fishing industry by introducing mechanization and modernizing fishing equipment such as cantrang, thus facilitating large-scale fish captures. Consequently, this investment has led to disparities between modern and traditional fishermen. In order to resolve inequality, the government issues subsidies for traditional fishermen in the form of fuel, infrastructure, marketing and income assistance. In general, this section supports the statement that increasing population and globalization means increasing economic performance, resulting in increased use of resources (Akhirul, 2020; Barlow, 2018) in accordance with the theoretical basis formed (**Section IIA**)

Autoregressive Variables Depict Overfishing
The modeling results include an autoregressive (AR) variable, which serves to address the issue of autocorrelation. Autocorrelation in this model arises from the presence of patterns or trends that create dependency between data observations over time, commonly referred to as the cobweb phenomenon. This phenomenon occurs due to the assumption of perfect competition in the market, production time for commodities, price determination based on market goods, and price fluctuations in commodities (Poitras, 2023). Within the modeling context, there are two types of AR variables: AR(1) and AR(5). Both autoregressive variables signify instances of overfishing, albeit with different durations and impacts.

AR(1)
A positive correlation is indicated by AR(1), implying that a rise in fish catches in the previous year leads to an increase in the biomass of fish catches. This variable suggests a rising pattern in fish catches. According to **(Section**

IIA.1), there is a preference among Indonesian people to consume fish meat as their income grows. Simultaneously, there was a surge in the human population during that period (TWB, 2018). This surge in food demand then leads to an increase in the production of fish catches.

AR(5)

The AR(5) indicates an inverse correlation, suggesting that an increase in fish catch biomass over the previous 5 years leads to a decrease in fish catch biomass. This factor reflects the decline in fish biomass attributed to demand pressure and the detrimental impact of the fishing industry over a 5-year timeframe. As discussed in the prior section (**Section IIA.2; Section IIA.3**), it is evident that overfishing results not only from demand but also from the influence of investments in cantrang equipment and government policies, exacerbating the situation. Over the long term, this stress and pressure contribute to the degradation of fish catch biomass.

Investment in cantrang has been linked to the degradation of aquatic ecosystems as a result of bycatch (Kominfo, 2017). Subsequently, the government implemented a ban on the use of cantrang. However, the ban was lifted after one year, despite its positive impact on addressing existing social disparities (Kasim, 2019). This incident illustrates the government's tendency to prioritize economic needs over the sustainability of marine ecosystems and traditional fishermens's wellfare (Gani, 2021; Karisma, 2020).

According to Barlow's research, the deterioration of tropical ecosystems can be attributed to the government's failure to effectively address existing issues (Barlow, 2018). This conclusion corroborates findings from reputable institutions such as the Oxford Business School and the United Nations, which indicate that certain Indonesian government officials are involved in corruption, offer little support, and overlook illegal activities in the field (Chapsos, 2019). For instance, Indonesian fishermen continue to engage in destructive fishing methods, leading to habitat destruction and a decline in fish population. The smuggling of destructive tools like bombs and poison from Malaysia through the Malacca Strait to various parts of Indonesia is contributing to these harmful practices. The intricate and elaborate network of this practice poses a challenge in terms of eradication and detection. In order to cater to the demands of both domestic and international markets, smugglers also serve as backers (punggawa) for local fishermen, thereby playing a significant role. The recruitment of fishermen is facilitated through trustworthy individuals to preserve secrecy. Financial resources and destructive tools are provided to fishermen engaged in harmful prasctices. Additionally, eradication efforts are hindered by the patronage's corrupt ties, creating obstacles for the authorities (Asri, 2019)

5. Conclusions

The research findings indicated two main points: (1) There is a strong correlation between forests and GDP, but they can still independently and simultaneously have a significant impact on fish catch. (2) The autoregressive variable demonstrates a trend in fish catching – in the short term (one year), it increases the biomass of caught fish, whereas in the long term (five years), it decreases the biomass of caught fish. Although the coefficient of determination is high at 99.9%, it is advisable for future research to utilize ARDL (Autoregressive Distributed Lag) due to the varying degrees of stationarity among the variables (Laloan, 2023). Furthermore, it is recommended to update the model annually due to the absence of cointegration between variables, which results in short-term correlations during model estimation

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