The economic development parameters and shrimp culture sustainability: Granger causality approach

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Abstract. Aquaculture is one of the fundamental sectors that play an optimistic key role in optimizing economic growth in Indonesia. Against such hope, over-exploitation of the existing fish stock, infamously known as overfishing, is an obstacle to Indonesia's sovereignty over controlling marine resources. This typical phenomenon is generally driven by various economic parameters that force some parties to take non-sustainable measures. Considering that the sustainability of fishery resources, especially *Penaeus merguiensis*, cannot be separated from the economic variables, specifically in the aquaculture development, this study aspires to find a causal relationship between gross domestic product, investment, and inflation toward the total shrimp production in Indonesia using pairwise Granger causality generated by the autoregressive distributed lag model. In favor of enriching the discussion and making recommendations, this study also discusses sustainable water quality parameters to maximize the production of *P. merguiensis* larvae culture using the RAPFISH method. The present study results reveal unidirectional causality between investment toward total production, inflation toward the gross domestic product, inflation toward total production, and inflation toward investment. The inflation variable unidirectionally affects the other three variables as it confirms that economic stability greatly influences Indonesia's economic fitness, particularly the total fishery production. Total production and gross domestic product mutually influence each other, confirming that these two variables must be optimized in order to give a positive effect mutually. In terms of sustainable development, the government must optimize policies that can emphasize the importance of sustainable aquaculture by taking into account the ecological dimension consisting of four attributes: (1) salinity; (2) temperature; (3) dissolved oxygen; (4) pH.
Key Words: causality relationships, economic fitness, total production, water quality parameters.

Introduction. Shrimp farmers are one of the community clusters with the most sensitivity to changes in the market economy, especially in any component that affects aquaculture productivity; their source of livelihood. Economic variables play an essential role in explaining the marine product market in the fisheries sector, including shrimp. At the same time, ecological attributes also have a significant influence in providing recommendations for economic approaches. Altogether, a productive fishery market could be achieved (Meltzer & Chang 2006).

A sustainable fisheries management desires to sustain fishery resources biologically and economically advantageous in the long term for the community's welfare (Cochrane 2002). In favor of achieving such an aspiration, the ecological aspect deserves broad attention as it is conceivable to have a causal relationship with economic variables. Without a doubt, those aspects certainly affect the sustainability of the fishery sector. Ayunda et al (2018) found that fisheries sustainability management can be investigated by looking at their biological, economic, and technological variables. They also acknowledged that fishing activities using sustainable tools would increase the efficiency for better management of fisheries resources.

Several studies (Deutsch et al 2007; Allison et al 2009; He 2015) believed that the successful development of the fisheries sector has an immense contribution to the national economy, for example, in Iceland, Norway, Thailand, China, and South Korea. Additionally, the fisheries sector in the countries as mentioned earlier has received political, economic, social, and government engagement and support.

The international market condition in the late 90s experienced fierce competition among the top three shrimp producers, such as Thailand, the Philippines, and Indonesia. As time passed, more precisely in the early 2000s, competition from shrimp-producing countries was getting fiercer. Even as this writing was completed, Harkell (2021) reported that Indonesia's position as a top producer was taken over by Ecuador, India, Vietnam, and China. Furthermore, the value of shrimp exports by China and Vietnam is the highest due to the great demand for high-quality shrimp products that they can meet. Such a condition shows the importance of the competitiveness of Indonesian shrimp in maintaining and winning the export market by increasing the shrimp's quality and quantity.

According to Zamroni et al (2021), the supply chain of shrimp culture in various regions in Indonesia is varied. These differences are generally influenced by the performance of facilities, hatchery processes, larvae quality, and fish processing units. Such disparities are evidently causing the quality, quantity, and logistics costs of shrimp culture to be considerably different, following their rooted values. This phenomenon undoubtedly answers why logistics expenses vary from one area to another. The combination of the uncompetitive price and low quality of aquaculture products offered by Indonesia is a significant threat to the local shrimp market. If the selling value of local products is weak, economic problems such as inflation will haunt the Indonesian shrimp market. This condition is exacerbated if sustainable cultivation management is not on the priority list.

Suhardi & Afrizal (2021) stated that the quality and competitiveness of the Indonesian shrimp export market are overall weak and unable to compete with similar products produced by competing countries, including Malaysia. Furthermore, Das et al (2012) said that strong global growth, growing capital flows, and prolonged stability make business market players stretch as much as possible. At the same time, there are still many market participants who lack knowledge regarding risk management practices. Therefore, consistent and coordinated macroeconomic policies are needed so that every actor in the economic sector understands the causality of all sectors adequately.

The economic crisis will inevitably have a very destructive impact on the country's stability. A study by Elahi (2013) found that a crisis and lack of risk management would lead to severe market disruptions. When the demand for fishery products is high but product quality is low, inflation is problematic to avoid. The situation where the product quality is low due to the lack of sustainable management will be further aggravated if the economic variables that serve as economic development barometers are also treacherous.

The adverse effect of not understanding the causality of the fishery sector with the economic sectors will disrupt the fishery industry as a whole. The inevitable impact will be felt by all parties, including processing companies and all fish traders. Generally speaking, everyone will suffer an extreme market slump. Ironically, over many community clusters, the fishers and fish cultivators are the most affected people as they find it difficult to obtain capital for investment since they rely on fish traders. When the price of productive materials rises but the rate of profit falls, money is tight for them. This situation will force fishers' financial condition to become even worse due to the decline in total production and production value. Shrimp cultivation, especially in coastal areas, is an integral part of national economic development, and the sustainability of the shrimp farming business also relies on environmental conditions. However, the environment is increasingly threatened due to irresponsible industrial waste management (Ejaz & Janjua 2012).

Given that *Penaeus merguiensis* is the possible alternative to complement *Litopenaeus vannamei* in Indonesia, maximizing the *P. merguiensis* cultivation industry can help bolster the country's revenues significantly. Moreover, the optimized benefit of

P. merguiensis cultivation will further improve the economic prosperity of coastal communities through massive job opportunities (Tull et al 2016).

In light of the above understanding, this paper aims to identify the associations between total fisheries production with Indonesia's economic development based on pairwise Granger causality by employing autoregressive distributed lag model (ADLM) using EViews v.10. Later, the fisheries sustainability attributes processed by RAPFISH (Rapid Appraisal for Fisheries) will complement the discussions toward the economic variables, specifically the total production variable.

Methods. This study employs time-series secondary data from 2006 to 2019 obtained from the publication series of the Indonesian Central Statistics Agency (2021a, b). The data employed are economic development indicators consisting of total fisheries production, gross domestic product (GDP), investment, and inflation. The data processing stage began by checking the stationarity of the time-series data through the unit root test. The unit root test was carried out to determine whether the times series data used was stationary or not. If the time series data was not stationary, making it stationary must be done through the differencing method. The number of differencing in the unit root test showed the order of integration of the time series data. The order I(0) to order I(1) was required for causality analysis. Therefore, all variables must be stationary before performing the autoregressive distributed lag (ARDL) model. If there was a stationary variable in the second difference, the ARDL model could not be applied. In favor of verifying whether any variable was integrated at second difference/I(2), the augmented Dickey-Fuller test by Dickey & Fuller (1979) was done in the stationary test stage. Technically speaking, the root test was used to identify orders from time-series data to avoid potential breaks. After knowing the stationarity level based on the unit root test, the data was processed to find the optimum lag.

This study used Akaike information criterion (AIC) to determine the optimum lag through vector autoregression estimates (VAR). Optimum lag was obtained by testing the total production variable as an endogenous variable while the rest as exogenous variables through the VAR lag order selection criteria. The smallest value of AIC was then chosen as the optimum lag. The results of selecting the optimum lag were then inputted when running ARDL cointegrating and long run form.

By adopting natural logarithm specification for all variables, the equations for the ARDL model for each variable as endogenous are as follows:

$$\Delta\ln GDP_t = \alpha_\circ + \alpha_T T + \alpha_{GDP} \ln GDP_{t-1} + \alpha_{TP} \ln TP_{t-1} + \alpha_{IF} \ln IF_{t-1} + \alpha_{IV} \ln IV_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta\ln GDP_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta\ln TP_{t-j} + \sum_{k=0}^{l} \alpha_K \Delta\ln IF_{t-k} + \sum_{l=0}^{m} \alpha_l \Delta\ln IV_{t-l} + \varepsilon_t \quad ....(1)$$

$$\Delta\ln TP_t = \beta_0 + \beta_T T + \beta_{TP} \ln TP_{t-1} + \beta_{GDP} \ln GDP_{t-1} + \beta_{IF} \ln IF_{t-1} + \beta_{IV} \ln IV_{t-1} + \sum_{i=1}^{p} \beta_i \Delta\ln TP_{t-i} + \sum_{j=0}^{q} \beta_j \Delta\ln GDP_{t-j} + \sum_{k=0}^{l} \beta_k \Delta\ln IF_{t-k} + \sum_{l=0}^{m} \beta_l \Delta\ln IV_{t-l} + \varepsilon_t \quad ....(2)$$

$$\Delta\ln IF_t = \phi_\circ + \phi_T T + \phi_{IF} \ln IF_{t-1} + \phi_{GDP} \ln GDP_{t-1} + \phi_{TP} \ln TP_{t-1} + \phi_{IV} \ln IV_{t-1} + \sum_{i=1}^{p} \phi_i \Delta\ln IF_{t-i} + \sum_{j=0}^{q} \phi_j \Delta\ln GDP_{t-j} + \sum_{k=0}^{l} \phi_k \Delta\ln TP_{t-k} + \sum_{l=0}^{m} \phi_l \Delta\ln IV_{t-l} + \varepsilon_t \quad ....(3)$$

$$\Delta\ln IV_t = \varphi_0 + \varphi_T T + \varphi_{IV} \ln IV_{t-1} + \varphi_{GDP} \ln GDP_{t-1} + \varphi_{TP} \ln TP_{t-1} + \varphi_{IF} \ln IF_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta\ln IV_{t-i} + \sum_{j=0}^{q} \varphi_j \Delta\ln GDP_{t-j} + \sum_{k=0}^{l} \varphi_k \Delta\ln TP_{t-k} + \sum_{l=0}^{m} \varphi_l \Delta\ln IF_{t-l} + \varepsilon_t \quad ....(4)$$

Note: GDP = gross domestic product;
TP = total production;
IV = investment;
IF = inflation;
t = trend variables composing the ARDL model and bound tests.

$\alpha_\circ, \beta_0, \phi_\circ, \varphi_0$ and $\alpha_T, \beta_T, \phi_T, \varphi_T$ are drift components and time trends, while ε_t is assumed as a white noise error.

By employing ARDL cointegrating and long run form through checking the bound tests developed by Pesaran et al (2001), this study tried to prove the presence or absence of cointegration. This approach was used because the ARDL cointegrating and long run form method is satisfactory in cointegrating tests with a small number of data samples (Shahbaz et al 2013).

$$\Delta\ln TP_t = \&\beta_{o1} + \sum_{i=1}^{l} \beta_1 \Delta\ln TP_{t-i} + \sum_{j=1}^{m} \beta_2 \Delta\ln GDP_{t-j} + \sum_{k=1}^{n} \beta_3 \Delta\ln IF_{t-k} + \sum_{r=1}^{o} \beta_4 \Delta\ln IV_{t-r} + \varepsilon_t \ldots.(5)$$

The cointegration results were then compared according to Pesaran et al (2001) concerning the upper and lower critical bound to conclude whether or not there is a long-run cointegration between variables. The hypotheses are as follows:

• F-statistic > upper critical bound (UCB), then there is cointegration;
• F-statistic < lower critical bound (LCB), then there is no cointegration;
• Lower critical bound (LCB) < F-statistics < upper critical bound (UCB), then the results are not convincing.

In order to find causality direction and bound tests through ARDL, our empirical framework investigation employed pairwise Granger causality tests. The test to discern the Granger causality was carried out using the Hsiao–Granger procedure in order to maximize the variation in height, avoid bias, and obtain a robust examination. By testing Granger causality using a tri-variate system, the TP as endogenous variable was set, while GDP, investment, and inflation were placed as exogenous variables.

The sustainable ecological parameters to maximize the production of *P. merguiensis* larvae in this study employed a RAPFISH multidimensional scaling (MDS) approach using water quality parameters as attributes for the ecological dimension (pH, dissolved oxygen (DO), temperature, and salinity). RAPFISH analysis began with determining the dimensions and attributes of a resource's sustainability to be analyzed (Alder et al 2000; Pitcher & Preikshot 2001; Adiga et al 2015; Hartono et al 2005). Then, data of water quality parameters were converted into an ordinal score based on the ordination technique, processing a set of fisheries aspects in an interval to facilitate the assessment of the sustainability index. The ecological sustainability status of RAPFISH will support the variables that influence the TP variable.

Results and Discussion. Pairwise Granger causality test can be found after proving the cointegration of variables. The requirement to see cointegration is by performing a cointegration test that defines whether the variable is stationary. This study found that all variables were stationary at the level I(0) and first-order I(1), as presented in Table 1.

Table 1

Unit root test by augmented Dickey-Fuller test

Variable	*t-statistics*	*Stationary level*	*Prob.**
Total production (TP)	-3.14261	1st difference	0.0036
Gross domestic product (GDP)	-3.469022	1st difference	0.0294
Investment (IV)	-3.439115	1st difference	0.0003
Inflation (IF)	-6.88723	Level/I(0)	0.0002

Stationarity testing in this study helps prove the presence or absence of unit roots as it helps the researcher identify features of the underlying series. It is defined as stationary if the data series has no unit roots. Fortunately, the current model is far from spurious regressions as they are all stationary. The unit root test using augmented Dickey-Fuller found that TP, GDP, and IV were stationary at the first difference or I(1), while the inflation variable was stationary at level or I(0). Engle & Granger (1987) stated that Granger causality could give invalid results if one variable is cointegrated into the second difference.

For the data to be processed on the ARDL, it is essential to determine the optimum lag of the TP variable. This process was carried out through the VAR lag order selection criteria, with the results presented in Table 2.

Table 2

A vector autoregressive lag order selection criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	30.70284	NA*	0.000983	-4.10813	-3.934299	-4.14386
1	33.78341	3.791463	0.000729*	-4.428216*	-4.210928*	-4.412879*

Note: * indicates lag order selected by the criterion; NA* = not available; LR = sequential modified LR test statistic (each test at 5% level); FPE = final prediction error; AIC = Akaike information criterion; SC = Schwarz information criterion; HQ = Hannan-Quinn information criterion.

As shown in Table 3, the optimum lag results (lag 1) show that the AIC with lag 1 is the best used in the model, marked with an asterisk (AIC with the smallest value). Because the results of the stationarity test prove that all variables are stationary at the level I(0) and first-order I(1), the ARDL cointegrating and long run form through the bound tests approach was carried out with lag 1 following the results of the optimum lag determination.

The bound tests approach was used to prove the presence or absence of cointegration between variables. The ARDL cointegrating and long run form result through the bound tests approach for the TP variable are presented in Table 3.

Table 3

ARDL cointegrating and long run form

Variable	*Coefficient*	*Std. error*	*t-Statistic*	*Prob.*
D(LNGDP)	0.001709	0.009601	0.178034	0.8637
D(LNIV)	0.069182	0.025155	2.75023	0.2852
D(LNIF)	-0.023466	0.020688	-1.134301	0.294
CointEq(-1)	-0.481205	0.197168	-2.440579	0.4472

As shown in Table 3, CointEq(-1) probability is not significant (greater than 0.05). To ensure that cointegration is not found, the TP as the dependent variable is then retested with bound tests. The bound tests result is presented in Table 4.

Table 4

ARDL bounds test

Test statistic	*Value*
F-statistic	0.472441

From the results of the bound tests, the F-statistic of 0.472441 was obtained. To further ensure that cointegration is not found in the ARDL model with TP as the dependent variable, the F-statistic from the ARDL bounds test results will be compared with LCB/I0 bound and UCB/I1 bound as presented in Table 5.

Table 5

Critical value bounds

Significance	*I0 Bound*	*I1 Bound*
10%	2.72	3.77
5%	3.23	4.35
2.50%	3.69	4.89
1%	4.29	5.61

Since the F-statistic of 0.472441 from bound tests results is smaller than the value of LCB/I(0), it is reaffirmed that the cointegration between TP and GDP, investment, and inflation is not found to be similar to the results described in ARDL cointegrating and long run form (Table 3). Therefore, the appropriate model has been carried out correctly (ARDL model) and can directly find the value of pairwise Granger causality.

The pairwise Granger causality test results found that three types of two causalities existed: unidirectional and bi-directional causality. Among variables of TP, GDP, investment, and inflation, the bi-directional causality was only found between the TP and GDP. Besides, unidirectional causality relationships were found: (1) investment toward TP; (2) inflation toward GDP; (3) inflation toward TP; (4) inflation toward investment. The results of pairwise Granger causality tests are presented in Table 6.

Table 6

Pairwise Granger causality tests

Null hypothesis	*Obs*	*F-statistic*	*Prob.*
LNGDP does not Granger cause LNTP	12	4.38441	0.0483
LNTP does not Granger cause LNGDP	12	2.50993	0.0150
LNIV does not Granger cause LNTP	12	2.16469	0.0185
LNTP does not Granger cause LNIV	12	0.20479	0.8195
LNIF does not Granger cause LNTP	12	2.52021	0.0149
LNTP does not Granger cause LNIF	12	0.88662	0.4537
LNIV does not Granger cause LNGDP	12	1.82282	0.2305
LNGDP does not Granger cause LNIV	12	0.03169	0.9689
LNIF does not Granger cause LNGDP	12	0.05038	0.0412
LNGDP does not Granger cause LNIF	12	3.45870	0.0902
LNIF does not Granger cause LNIV	12	0.76297	0.0415
LNIV does not Granger cause LNIF	12	0.50397	0.6245

Investment toward total production (unidirectional). Investment determines the integrity of economic activity since investment adds the capability of capital stock and contributes to economic growth. According to Sukirno (2006), the investment represents an acquisition by a party to purchase goods and production equipment such as buildings, equipment, machines, and human resources, which are expected to provide benefits and increase the ability to produce goods and services. The investment variable that Granger causes the total production in this study confirms that investment can increase fishery productivity, represented by the number of catches. The present study's findings were strengthened by Ogundari & Ojo (2009), who analyzed the income generation potential of aquaculture farms in alleviating household poverty. They found that if the investment production of aquaculture is increased, the value of the income will increase, resulting in the GDP of fisheries in Indonesia increasing even more.

Aquaculture has a high economic value as an export commodity. Due to its strategic production value for the national economy, aquaculture's contribution will be very profitable to alleviating poverty by opening up expansive employment opportunities (Aswicahyono et al 2011). In addition, aquaculture with a promising investment will also increase the value of production, which can increase people's income. As a source of a country's foreign exchange, fishery production should be optimized by prioritizing a sustainable aquaculture system so that aquaculture yields continue to increase.

According to Lindsay et al (2020), imperfections and inequalities between market exercises and ecological feedback are essential determinants influencing the fishery's economic success, including the policymaking. Therefore, the government and business actors in the fisheries sector are expected to strengthen TP by considering ecological feedback that affects the optimal living environment for the production of *P. merguiensis* culture. Furthermore, strengthening investment should also be done through increasing law enforcement capabilities by ensuring that capital for optimizing sustainable aquaculture is utilized for its proper purpose.

Avoiding problematic aquaculture funding is indeed tricky. Therefore, government interventions on investment in sustainable aquaculture must be accentuated so that investment can truly positively affect total production, especially *P. merguiensis*.

Inflation toward gross domestic product (unidirectional). Surprisingly, this study found that inflation has a unidirectional causality to all other variables. This finding indicates that inflation has a significant impact if it is positioned as the primary variable in the economic development of the fisheries sector. Although inflation does not necessarily paralyze economic development in a short time, continuing high inflation can have various effects on economic activity. Sukirno (2006) stated that production costs that persist in rising cause productive activities to become weak, and in this condition, investors would increasingly have more chances of not investing their capital. The impact that can be felt the most is that the price of local goods will be difficult to compete with international products.

Furthermore, uncontrolled inflation can cause local goods to be much more expensive than international ones. As a result, local consumers have a high preference for exported products. A high preference for export products in the fishery sector will lead to higher inflation. The inability of local products to compete with international products, especially in terms of price, will weaken the selling power of local products and lower the income of the country's community, specifically the fishers. Therefore, the worst impact of high inflation on the fisheries sector is weakening the fishers' income level.

According to Adhuri et al (2016), Indonesia is one of the forefront producers of marine products globally, and small-scale fishers dominate these production activities. Therefore, when a few people have the ability to increase their income during high inflation, fishers, as people with limited privilege, will experience a very significant decrease in real income.

The weakening of the local economy is destructive to the sustainability of small community fishing activities. The present study's findings are supported by Lindsay et al (2020), who conducted a blue economy prediction model in South Sulawesi regarding the characteristics and activities of the fishing community. They found that the characteristics of fishers with relatively high isolation from regional markets make accommodation costs expensive and result in price inequality for products offered in the market. Therefore, when product prices are already expensive due to regional isolation, inflation will undoubtedly have a very destructive effect on the competition for products offered, especially by small fishing communities.

Inflation toward total production (unidirectional). Production costs, maintenance costs, and TP are non-separable elements in the aquaculture sector. Nuraini et al (2007) stated that production costs are all expenses or responsibilities producers must bear to produce goods or services to end customers. For consumers, inflation will provide the concept that the price of goods and services will continue to rise. As a result, consumers will purchase everything greedily because they think the current price will increase daily. Such consumer behavior will increase demand and force the market to provide the goods needed in a short time with more expensive production costs. At the same time, manufacturers are also not hesitant to hold on to their sales and wait until the price of goods continues to rise in order to generate higher revenue. Such a situation will cause the product's competitiveness to be plunging, especially in terms of quality.

According to Sujatmiko & Arifin (2019), who examined the effect of GDP and the exchange rate on shrimp exports, the GDP of the importing country increases when local people have more preferences toward export products. As a result, many needs cannot be met by domestic production but by exporters. Consequently, the demand for imported shrimp will be higher, and inflation will also be heightened. Therefore, the two variables will undoubtedly affect the exchange rate.

Since the present findings show that inflation Granger causes the total production, extreme inflation can disrupt economic stability, raise raw material prices, and distort estimates of future economic activity. The findings in the present study are supported by Mohani et al (2016), who analyzed the effect of the international shrimp price variable, the amount of shrimp production, and the Rupiah exchange rate on shrimp exports. With multiple linear regression analyses, they found that monetary inflation had a significant effect on the volume of Indonesian shrimp exports. Therefore, the present study proves that inflation, which is also influenced by fluctuations in the exchange rate, will affect TP. Thus, in order to maintain TP, inflation must be controlled.

Inflation toward investment (unidirectional). Fit economic conditions will entice a much larger number of investors as it is assumed to be a damper for various types of shocks yet is an attraction for investors. When inflation is controlled, people will be able to adjust their income and consumption. Aquaculture cultivators will be able to obtain the production materials they need because the cost of production is within the limits of their purchasing power. Therefore, a healthy economic status will attract many investors and create jobs. Based on the Granger causality test between inflation and investment, it is assumed that investment depends on the position of inflation, which will ultimately affect the TP variable. The scarce investment will make it difficult for those who need jobs due to inactive economic mobility.

According to Soetrisno (2004), *P. merguiensis* is relatively difficult to produce due to the scarcity of this species in nature. However, *P. merguiensis* is one of the national shrimp species whose production is the most important, next to *Penaeus indicus* and *Metapenaeus monoceros*. Therefore, if the sustainability of this shrimp type is maximized, Indonesia will be able to dominate the local and global shrimp market, which will undoubtedly impact the national economy. Oppositely, if economic activity is plunging steeply due to inflation, people's welfare will slow down. Moreover, dissatisfaction with economic status in the community will lead to various speculations and cause several aquaculture groups to be very vulnerable to bad influences such as aggressive and violent actions due to poverty.

Total production and gross domestic product (bi-directional causality). Shrimp is a fishery commodity with the tremendous economic potential to be maximized to complement other types of superior marine products. Although shrimp is one of the dearests Indonesia's non-oil and gas export commodities from the fisheries sector (Maharani et al 2009; Isdadiyanto 2015; Untsayain et al 2017), the production value fluctuates from year to year with significant drops.

The causal relationship between TP and the GDP is influenced by feedback on TP output. The present findings are supported by Ali & Rehman (2015), who stated that instability in economic changes that affect many societies, companies, and markets significantly affects the GDP. From a microeconomic perspective (Payne 2010), consumption increases when output or production increases. Therefore, if TP performs splendidly and is accompanied by high stability of purchasing power, the income and production capacity will be higher. On the other hand, when GDP is high, the capital formation will also be high, encouraging economic growth. The two-way relationship between TP and GDP shows that a high production value resulting from high-yielding activity can encourage growth and vice versa. The results of this study are supported by Hameed et al (2010), who stated that a satisfactory TP accompanied by high investment would have a multiplier effect on national income.

Therefore, TP has a direct effect on national income in return. In addition, such activities will increase the attention of investors to invest and will undoubtedly improve the formation of capital for a more productive fishing industry.

Sustainable ecological dimensions. Alder et al (2000) defined the ecological sensitivity value for the sustainability of shrimp larvae development: (1) index value of 0.00-25.00 as unsustainable; (2) 25.01-50.00 as less sustainable; (3) index value of 50.01-75.00 as entirely sustainable; (4) index value of 75.01-100.00 as very sustainable.

Figure 1 shows leverage values of each attribute on the ecological dimension in this study: (1) salinity (87%); (2) temperature (82%); (3) DO (81%); (4) pH (77%). Since salinity and temperature are the two parameters with the largest values, the local

P. merguiensis larvae in the present study are believed to be most influenced by salinity and temperature compared to other water quality parameters.

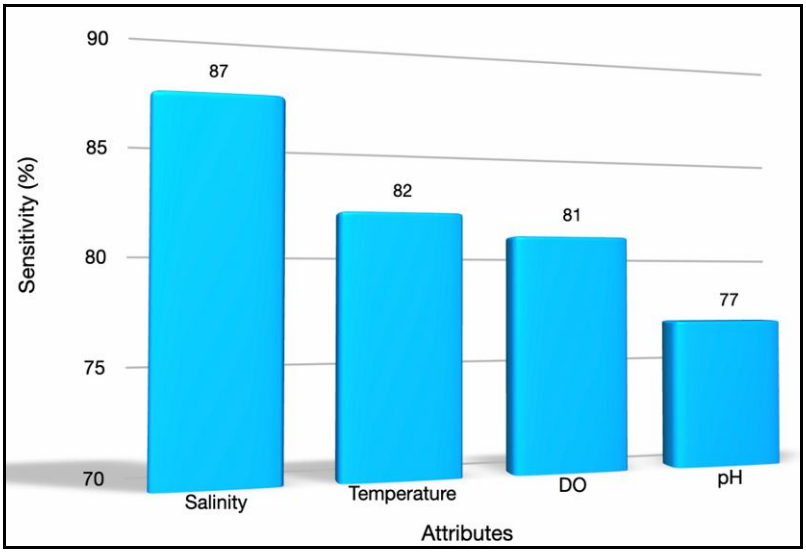

Figure 1. Sensitivity of ecological dimension.

By looking at the sustainability index of shrimp larvae development (Alder et al 2000), the results of RAPFISH in the present study found that all water quality parameter attributes were categorized as highly sustainable. Specifically, salinity and temperature are the two parameters with the most significant sensitivity.

Attributes that become the assessment variables of the ecological dimensions in this study play a substantial role in the development of shrimp larvae and are identified as sensitive factors to the sustainability of shrimp larvae cultivation. Besides the ecological dimension that helps support sustainable shrimp farming, other variables with more complexity also determine the shrimp farming success, covering the characteristics of the farming system, feed quality, management, and manual control of the water's physical aspects (Lorenzen & Camp 2019). Therefore, the management system must continue to monitor changes in variables applicable to shrimp farms. Furthermore, in achieving a more sustainable shrimp culture, optimal ecological dimensions cannot stand alone considering that these variables are also influenced by the tendency of the community's economy, especially fishing communities which are very sensitive to cost changes.

Modern cultivation of *P. merguiensis*, as in other types of shrimp, began in the late 1960s. At that time, several studies believed that *P. merguiensis* could tolerate a reasonably comprehensive salinity (Dall 1981; Camacho-Jiménez et al 2017), which means that their metabolic ability is not significantly affected by low salinity. However, as a sensitive parameter found in the present study, salinity must deserve a more appropriate concern.

Besides, *P. merguiensis* is believed to be one of the strongest candidates to complement *L. vannamei* due to its higher immunity to disease. Such characteristics hopefully could allow the cultivation of *P. merguiensis* to be carried out by rural communities. Therefore, practitioners in the shrimp farming industry must carefully regulate the development strategies applied to achieve the expected output, especially for small-scale shrimp farming of *P. merguiensis.*

The results of the sustainability status analysis are expected to be constructive feedback for better management of shrimp aquaculture. Pitcher et al (2013) stated that RAPFISH is exceptionally useful in evaluating fisheries sustainability, conducting an analysis of ecosystem-based fisheries management, and checking the level of compliance of responsible fisheries.

Therefore, in building economic excellence, the government must formulate policies with a basis on strengthening sustainable shrimp farming as this sector is responsible for national economic resources. One of many ways to bolster the nationwide shrimp farming productivity is by prioritizing the quality of total production through the adoption of sustainable aquaculture while optimizing technological functions. Besides, encouraging local and foreign investors to intensify capital in the fisheries sector can optimize the total production, increase cultivation facilities, and speed up the adoption of knowledge transfer from experts (Saleh et al 2020).

To some degree, fishery production in Indonesia is dominated by marine fisheries (Figure 2) aiming only to achieve the maximum yield, hoping that the production value will increase.

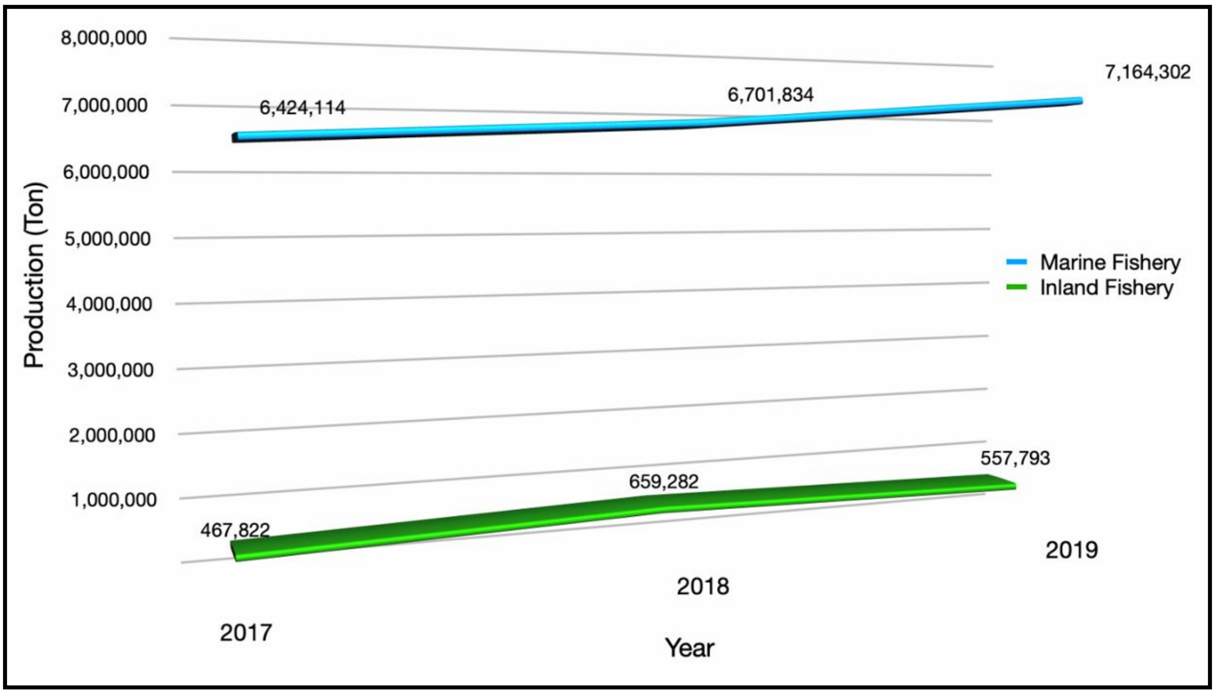

Figure 2. Capture fishery production by type of catch.

Data compiled from the 2021 Indonesian Central Statistics Agency stated that marine fishery dominated the capture fishery production by type during 2017-2019 with a total of 20 million tons. Although Figure 2 shows that the marine fishery always experiences an increase in total production every year, the inland fishery representing the culture fishery frankly experienced a significant decline from 2018 to 2019, losing 100 thousand tons.

Fishery products are one of the food sources consumed by almost everyone from the household to industrial scale. Meanwhile, the fishery sector is widely characterized by the classical and economic facets of coastal communities. Given that coastal communities are the most vulnerable group to economic fluctuations due to their fragile stance (Phillips 2004; Gonzalvo et al 2015), assessing the impact of policies that also cover the supply of human resources, the character of aquaculture, and total fishery production is considered necessary.

Ironically, one of the causalities that navigate aquaculture production to suffer in low quality is the environmental degradation experienced by pond cultivators. Environmental damage will directly impact product cultivation, and shrimp disease suffered by people on the northern coast of Java and Sulawesi in recent years has been the most severe threat to the value of nationwide aquaculture production (Malik et al 2017). Therefore, the role of the government in improving and stabilizing shrimp farming productivity as one of the economic drivers in the fishery business is necessary, considering that aquaculture has a high economic value through various means. Therefore, seeking and solving problems in the farming industry is vital for aquaculture farmers to elevate their source of income.

Conclusions. This study proves that the economic variables associated with sustainable analysis will be mutually reinforcing. The pairwise Granger causality tests on all variables found a unidirectional causality relationship between investment and total production, inflation to gross domestic product, inflation to total production, and inflation to investment. The inflation variable unidirectionally affects the other three variables, confirming that economic stability greatly influences Indonesia's economic conditions, especially the total fishery production. Furthermore, total production and gross domestic product mutually influence each other, confirming that these two variables must be optimized to affect each other positively. In terms of sustainable development, the government must optimize policies that can emphasize the importance of sustainable aquaculture by taking into account the ecological dimension consisting of four attributes: (1) salinity; (2) temperature; (3) dissolved oxygen; (4) pH.

Given that Indonesia's area is 5,180,053 km^2 with a sea of 3,257,483 km^2, it is understandable that 62% of such area certainly must triumph with its fishery products. Therefore, the Indonesian fishery sector in the future should become a priority so that the contribution of total production and production value of fishery products will increasingly have a positive impact on Indonesia's status as a maritime country. There is no doubt that the fisheries sector will strengthen Indonesia's economic growth.

The first recommendation goes to the government as they must protect the domestic market so that local products can compete in terms of price and quality. It is advisable for Indonesia to protect the domestic market by controlling inflation variables that can affect three other variables: total production, gross domestic product, and investment.

Secondly, the government and other related parties, including business actors in the fishery sector, are expected to strengthen total production by considering the sustainability of *P. merguiensis* through proper treatment that affects the sensitivity of shrimp's living environment. Fair total production is influential with the gross domestic product, which is one indicator of economic development that can demonstrate national and regional economic fitness. Thus, it is expected that total production can be carried out optimally.

Lastly, Indonesia must adopt a combination of preventive measures for the economic and ecological sectors so that the mobility of the national economy can stand firm without being too dependent on global market phenomena.

Conflict of interest. The authors declare that there is no conflict of interest.

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