



Exploring Aquaculture Fish Production: The Case of South Aceh District

Muti'ah¹, M. Shabri Abd. Majid^{2*}, Chenny Seftarita² and Yahya³

¹Master of Development Economics, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Jl. Teuku Nyak Arief, Kopelma, Darussalam, Banda Aceh 23111, Aceh Province, Indonesia

²Department of Economics, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Jl. Teuku Nyak Arief, Kopelma, Darussalam, Banda Aceh 23111, Aceh Province, Indonesia

³Department of Management, Sekolah Tinggi Ilmu Ekonomi Sabang (STIES), Jl. Prada Utama 15, Peurada, Syiah Kuala, Banda Aceh 24415, Aceh Province, Indonesia

*Correspondence :
mshabri@unsyiah.ac.id

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Abstract

This study empirically explores factors determining the production of fish aquaculture in the South Aceh District, Indonesia. The study selected 150 out of 1,893 aquaculture fish farmers within 18 sub-districts in the regency as the study's respondents using a multi-stage sampling technique. Primary data collected through questionnaires' distribution were analyzed employing a multiple regression model. The research documented empirical evidence that fish pond area, number of fish farmers, and capital significantly and positively influenced the production of fish aquaculture in the South Aceh Regency. Meanwhile, the number of fish seeds had an insignificant impact on the production of fish aquaculture. These empirical results suggested that in improving aquaculture fish production, fish farmers have to possess an adequate amount of capital, pond area, and the number of workers. Soft loan assistance sourced either from the government or banking institutions, conversion of idle and abandoned lands into fish ponds, and various fisheries capacity building programs is among the strategic steps that require to be taken to extend aquaculture production.

INTRODUCTION

As a maritime country, Indonesia has agribusiness potential in the fisheries sector (Ministry of Marine Affairs and Fisheries, 2019). Of the 34 provinces in Indonesia, Aceh is one of the provinces that has a long coastline with a water area of 295,370 km² (Central Bureau of Statistics, 2019). The geographical location of Aceh which borders the sea coast encourages the majority of Acehnese people to choose to work as fish cultivators or fishermen.

In the last ten years, the production of captured fish and fish farming in Aceh Province continues to show an increasing trend. Table 1 illustrates the increase in the average production of capture fish and aquaculture, respectively, by 9.60% and 12.79% during the period 2011-2018. Of 104,245 tons of aquaculture fish production in 23 regencies/cities in the Aceh region in 2018, the number of aquaculture fish production in the South Aceh Regency was reasonably low,

accumulating only 0.29% to the total production in Aceh Province.

Even though with its geographical location which reaches 16,173 km² along the shoreline of the Indian Ocean and its

population is fishermen-dominated, South Aceh Regency has not fully benefited from its great fishery production potentiality (Department of Marine and Fisheries, 2018).

Table 1. Catch fish and aquaculture fish production in Aceh Province 2011-2018.

Year	Catch Fisheries (Ton)			Aquaculture Fisheries (Ton)		
	Sea (Tons)	Growth (%)	Public Water (Tons)	Growth (%)	Aquaculture (Tons)	Growth (%)
2011	143,680.20	1.20	2,289.90	20.02	37,225.30	6.07
2012	145,833.60	1.50	1,352.20	- 40.95	40,215.40	8.03
2013	153,692.50	5.39	1,576.00	16.55	46,911.90	16.65
2014	157,943.70	2.77	1,543.80	-2.04	51,020.90	8.76
2015	165,778.80	4.96	1,569.55	1.67	64,081.89	25.60
2016	182,464.40	10.06	1,726.40	9.99	82,692.10	29.04
2017	236,061.00	29.37	3,297.00	90.98	99,539.00	20.37
2018	288,034.00	22.02	5,544.00	68.15	104,246.00	4.73
Mean	184,187.52	9.60	1,907.83	20.64	60,240.92	12.79

Source: Adapted from Central Bureau of Statistics of Aceh Province (2011-2019).

In 2017, the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia has designated South Aceh Regency as one of the ten culinary centers in Aceh Province. To support this culinary center, the government has built fish marketing facilities and infrastructure in the South Aceh Regency (Ministry of Marine Affairs and Fisheries, 2019). However, this culinary center has not been fully utilized to serve aquaculture fish menus.

As one of the districts that have been designated as a center for the

development of fishery product processing, the total aquaculture fish production in the regency is still very low when compared to other Aceh fish processing areas, such as Banda Aceh (Lampulo), Bireuen, (Cot Batee Glungku), and East Aceh (Idi). As illustrated in Figure 1, after 2009 the amount of aquaculture production in South Aceh declined drastically to its lowest point (65.85 tons) in 2013, and then increased slowly (Central Bureau of Statistics of Aceh Province, 2020).

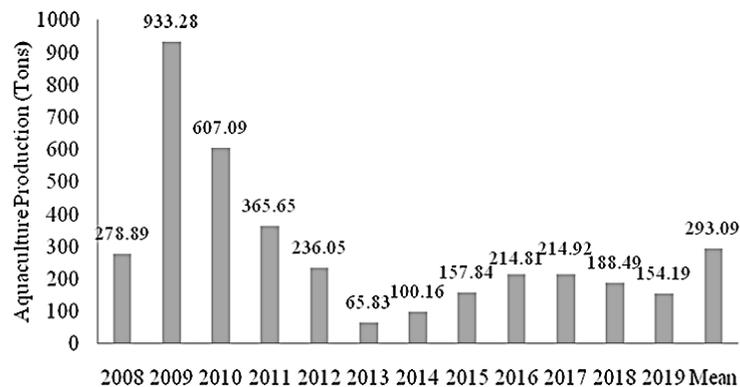


Figure 1. Aquaculture fish production in South Aceh District 2008-2019 (Central Bureau of Statistics of South Aceh Regency (2009-2020)).

The fluctuating and low production of fish aquaculture in the South Aceh Regency raises various scientific questions.

Why did this occur in South Aceh Regency, even though the natural circumstances and geographical sites of the South Aceh

Regency have enormous potential as one of the aquaculture fish production centers in the province of Aceh?

A bulk of previous research has explored the factors determining fish production. The number, quality, gender, and wages of labor (Andriyanto *et al.*, 2013; Wang, 2014; Akram *et al.*, 2019; Halim and Susilo, 2016; Elsner and Isphording, 2017) are among the determinants of fishery production. In addition, working capital also plays an imperative role in the processes of production (Andayani, 2016; Munandar and Sari, 2019). Lack of capital has caused a low production of small-scale fish farmers (Sutanto and Imaningati, 2014), traditional and modern fishermen (Yasrizal, 2017). Aquaculture fish production is also influenced by the quality and quantity of fish seeds, considering that aquaculture fish production starts with fish seeds (Sutanto and Imaningati, 2014; Negara *et al.*, 2017). The adequacy of fish seeds has a positive influence on the soft shell crab (*Scylla* sp.) production in Langkat Regency, North Sumatra (Nasution *et al.*, 2014).

In addition to the above factors, land area is also documented as the determinant of aquaculture fish production (Andriyanto *et al.*, 2013; Rinaldi *et al.*, 2015). Availability of adequate land could accommodate a larger number of fish seeds and avoid fish overcrowded (Negara *et al.*, 2017; Kumaran *et al.*, 2018; Kumaran *et al.*, 2020). The density of the number of seeds which is higher than the carrying capacity of the land area has led to a high risk of vannamei shrimp production (Ray *et al.*, 2010).

Compared to earlier relevant researches, this present study has four distinctive characteristics. First, unlike preceding studies that focused more on the factors determining marine caught fisheries production (Halim and Susilo, 2016; Wang, 2014; Yasrizal, 2017), the present research focused its analysis on the aquaculture fish production'

determinants. Second, while previous research focused on one type of cultured fish (Negara *et al.*, 2017; Munandar and Sari, 2019), the focus of the present study is on the sort of community fish aquaculture. Third, previous studies were more dominant in measuring factors of seasons, capital, fishermen experience, the quantity of labor, technology, and the size of land area (Nasution *et al.*, 2014; Rinaldi *et al.*, 2015), this study included the fish seeds as one of the factors determining aquaculture fish production.

Lastly, previous studies have explored the aquaculture fish production' determinants in Langkat Regency, North Sumatra (Nasution *et al.*, 2014) and Rokan Hulu Regency, Riau (Rinaldi *et al.*, 2015), and no similar research on this topic have been conducted in the South Aceh District. Thus, the present study intends to fill the gaps of previous researches by exploring factors determining fish farming production in the South Aceh Regency. These are among the foremost novelties of the study.

More specially, this study intends to empirically explore and scrutinize the factors determining aquaculture fish production in the South Aceh Regency, Indonesia. These factors include the size of land area, number of fish seeds, capital, and labor. The findings of the research are hoped to be advantageous to fish farmers, government related-authorities, banking, and financial institutions in formulating policy to support an enhancement in aquaculture fish production in the South Aceh Regency and other territories that possess comparable aquaculture fish characteristics in Indonesia.

METHODOLOGY

Place and Time

This research was conducted on 150 fish farming fishermen in all 18 sub-districts within the territory of the South Aceh Regency government, Aceh Province, Indonesia during August and September 2020.

Research Design

This study gathers primary data through questionnaires' distribution to 150 selected aquaculture fishermen. The study uses a multi-stage sampling technique, namely a combination of cluster sampling technique and stratified random sampling technique to select the study's respondents or sample out of 1,893 fish farmers spread within 18 sub-districts in the South Aceh Regency (Department of Marine and Fisheries, 2018). The selected sample is hoped to represent the whole population.

Work Procedures

This research explores four factors (independent variables), namely the amount of capital, land size area, the number of labors, and fish seeds determining aquaculture fish production (dependent variable) in the South Aceh District. This research measures the amount of capital by the total incurred expenses that are routine costs to purchase, preserve or restore fish farming amenities in Indonesian Rupiah (IDR) per harvest. Labor is measured by the average daily wages paid per harvest to the workers who are directly and indirectly involved in aquaculture fish production, such as managing and maintaining fish ponds, sowing seeds, raising fish as well as harvesting fish.

Moreover, land area is the size of pond area utilized for aquaculture fish production, computed in hectares per harvest. The number of fish seeds is the total cost incurred for purchasing fish seeds utilized in aquaculture fish production, calculated in the IDR per harvest. Lastly, aquaculture fish production is computed as the total fish production in kilograms (kg) multiplied by the fish selling price per kg measured in IDR per harvest (Olayiwola, 2013).

Data Analysis

The data collected were tabulated according to research needs and analyzed

using multiple regression techniques. This method has several interesting statistical properties that make it one of the most potent and popular regression analysis methods (Asteriou and Hall, 2015). By applying classical linear assumptions, this method provides an unbiased, linear, and minimum variance estimator, or called the Best Linear Unbiased Estimator (BLUE).

Before estimating the interaction between variables, the classical assumption tests were first performed on the research variables, comprising tests of normality, multicollinearity, and heteroscedasticity. Jarque-Bera test (J-B) was used to test for normality. If the J-B test value is lesser than the specified significance level, then the data is declared normally distributed. Meanwhile, Tolerance Value (TV) and Variance Inflation Factor (VIF) was used for the multicollinearity test. If the TV value is larger than 0.1 or VIF is less than 10, then the data is concluded to be free from multicollinearity problems. Finally, the Breusch-Pagan (B-P) test was used to test the heteroscedasticity of the data. If the B-P test value is higher than the specified probability value, then the data is declared homoscedastic (Gujarati, 2012).

Generally, the production function explored in this study follows the Cobb-Douglas model (Rahim *et al.*, 2019). The general production function that describes the relationship between input and output can be written in the following equation:

$$Q = f(X_1, X_2, X_3, X_4)$$

Where:

- Q = total production of aquaculture
- X_1 = land area
- X_2 = fish seeds
- X_3 = total labor
- X_4 = total working capital

Furthermore, the production function in the equation above is rewritten into the following Cobb-Douglas production equation:

$$Q = a.X_1^{\beta_1}.X_2^{\beta_2}.X_3^{\beta_3}.X_4^{\beta_4}$$

Where:

- Q = output
- X_1, X_2 = types of inputs used in the production process and considered for review

- α = efficiency index of using inputs in producing output
 β = production elasticity of the inputs used

Furthermore, the Cobb-Douglas production model can then be transformed into the following multiple regression equation:

$$\text{LnProd} = \text{Ln}\alpha + \beta_1\text{LnLand} + \beta_2\text{LnSeed} + \beta_3\text{LnLabor} + \beta_4\text{LnCapital} + \varepsilon$$

Where:

Prod = fish aquaculture total production

Land = the size of pond area

Seed = total fish seeds

Labor = total number of labors

Capital = total working capital

α = intercept

β =

if = predicted regressors values for each independent variable

ε = error term

All variables are transformed in the logarithmic form to provide more valid and reliable results.

RESULTS AND DISCUSSION

Brief Overview of Fish Aquaculture in the South Aceh District

Administratively, the South Aceh Regency with the capital regency of Tapak Tuan has a total population of 235,115 people in 2018, residing across 18 sub-districts (*Kecamatan*) (Central Bureau of Statistics of South Aceh Regency, 2019). The regency is bordered by Aceh Singkil District and the Indian Ocean in the south, the Indian Ocean and Southwest Aceh District in the west, Gayo Lues, Southwest Aceh, Southeast Aceh, and Subulussalam Districts/City in the north, and Aceh Singkil, Gayo Lues, Aceh Southeast, and Subulussalam Districts/City in the east. Of the total population, 1,893 people in South Aceh are fish cultivators

(Department of Marine Affairs and Fisheries, 2018). Of the total aquaculture fishermen, the study selected 150 of them as the study's respondents who have diverse socioeconomic backgrounds, as illustrated in Table 2.

From the aspect of age, most of the fish cultivators were in the age category between 26-30 years old (23%) and only 1% of them were in the age category of over 60 years old. In terms of education, the majority have high school education/equivalent (51%), followed by undergraduate's degree (36%), junior high school/equivalent (10%), and elementary school/equivalent (3%). The majority of them earned a mean monthly income of above IDR3 million (62%), and none of them earned a mean monthly income lesser than IDR1 million. Most aquatic fisheries employed 1-2 workers (74%), and only 1% of aquaculture farmers employed more than four workers. Judging from the type of fish, they generally raise tilapia (82%), followed by catfish (13%), goldfish (3%), and gourami (2%).

In general, aquatic fishermen have a pond area of 501-2,000 hectares (29%), and only 2% own a land area of more than 9,500 hectares. The purchase price of fish seeds generally ranges from IDR301-350 per unit (72%) and the highest purchase of fish seeds is above IDR550 per unit (1%). The majority of them spent buying fish seeds worth IDR1.5-2 million (36%) and only 1% spent buying fish seeds which were more expensive than IDR4.5 million (1%). Overall, the majority of them invested IDR9-11 million (35%), and only 1% of fish cultivators spent a total capital of more than IDR22 million.

Table 2. Descriptive statistics.

Age (Year Old)	%	Education Level	%	Monthly Income (IDR000.000)	%
<25	11	Elementary School	3	<1	0
26-30	23	Junior High School	10	1- 2	9
31-35	12	Senior High School	51	2-3	29
36-40	11	Undergraduate	36	>3	62
41-45	12	Types of Fish:		Total Labor (People):	
46-50	11	Gourami	2	1-2	74
51-55	9	Goldfish	3	2-3	23
56-60	9	Catfish	13	3-4	2
>60	1	Tilapia	82	>4	1
Land Area (Hectare)		Seeds Price /unit (IDR)		Total Cost of Seeds (IDR000.000)	
<1,000	14	< 250	2	< 1	22
501-2,000	29	250 – 300	12	1-1.5	36
2,001-3,500	22	301 – 350	76	1.5-2	20
3,501-5,000	9	351 – 400	1	2-2.5	14
5,001-6,500	16	401 – 450	4	2.5-3	2
6,500-8,000	5	451 – 500	1	3-4	3
8,000-9,500	3	501 – 550	3	4-4.5	2
>9,500	2	>550	1	>4.5	1
Total Capital (IDR000.000)		Selling Price/Kg (IDR000)		Total Production (Kg)	
<5	6	<30	21	<400	22
5-8	34	30-35	32	401-600	51
9-11	34	36-40	34	601-800	18
12-13	16	41-45	8	801-1,000	3
14-16	7	46-50	2	1,001-1,200	4
17-19	2	51-55	2	1,201-1,400	1
20-22	0	56-60	1	1,402-1,600	1
>22	1	>60	0	>1,600	1

Source: Primary Data, 2020 (Processed).

Finally, in terms of the selling price, generally, they sell it at IDR 36,000-40,000 per kg (34%) and only 1% of farmers sell their fish at a price above IDR 60,000 per kg. The number of fish produced by water cultivators, in general, is 401-600 kg per season (51%), and only 3% of farmers could produce fish above 1,000 kg per season. This demonstrates that aquatic fish cultivators in the South Aceh Regency were categorized as small-scale businesses either looked at from the perspectives of inputs or outputs. The role of the government is needed both in terms of funding and increasing the capacity of fish farmers to increase fish productivity.

Determinants of Aquaculture Fish Production

Before measuring and analyzing the determinants of aquaculture production, this research first ensures the fulfillment of classical assumptions, normality, non-multicollinearity, and homoscedasticity for all research variables. As illustrated in the last row of Table 3, the research documented that all variables examined in our research were found to be normally distributed, as indicated by the probability value of the Jarque-Bera Test (J-B) which was lower than the 5% significance level.

This study also recorded no problem of multicollinearity, as indicated by the Variance Inflation Factor (VIF) value ranging between 2.773 to 4.432 and Tolerance Values (TV) ranging between 0.231 to 0.371. A VIF value that is lesser than 10 and a TV value that is greater than 0.1 indicated that the independent

variables were multicollinearity-free (Gujarati, 2012). Lastly, the data of this study were also found to be homoscedastic as indicated by the probability value of the Breusch-Pagan Test (B-P). By and large,

these empirical results indicate that our data have met all classical assumptions; hence, they can be further estimated in our proposed research model.

Table 3. Estimated findings of the factors determining fish aquaculture production.

Variable	Estimated Coefficient	t-statistics	Prob.
Constant	1.902	1,623	0.122
Land Area	0.132**	2,271	0.043
Fish Seeds	0.015	0,243	0.832
Labor	0.221***	2,876	0.005
Capital	0.646***	5,442	0.000

F-Stat = 89.127; F-Stat (Prob.) = 0.000. J-B (Prob.) = 0.003 – 0.056; VIF = 2.773 – 4.432; TV = 0.231 – 0.371; B-P (Prob.) = 0.312; $R^2 = 0.778$; Adj- $R^2 = 0.763$;

Note: *** and ** indicates significance at the 1% and 5% levels. J-B (Jarque-Bera) is adopted for normality test; VIF (Variance Inflation Factor) and TV (Tolerance Value) are used for multicollinearity test; B-P (Breusch-Pagan) is utilized for heteroscedasticity test, and Prob. is a probability value (p-value).

Table 3 presents the findings of the factors determining aquaculture fish production in the South Aceh District. As reported in Table 3, the predicted constant value was documented to be insignificant. This shows that the production process of fish aquaculture would fail if it is not supported by the existence of an adequate pond area and a sufficient number of workers and capital. The results of the study imply that the availability of inputs is the main requirement for aquaculture production; without its availability, the production of fish aquaculture would not be successful. These empirical results are further reinforced by the 1% level of significance of the forecasted adjusted determination coefficient (Adjusted- R^2) of 0.763. This finding signifies that 77.90% variations in the production of fish aquaculture are explained by fluctuations in the pond area, fish farmers, fish seeds, and capital used. Meanwhile, aquaculture fish production's variations in the South Aceh Regency were only 22.10% caused by changes in other factors that were not explored in the study. These factors include seasonal changes, competition in the fish market, fish diseases, etc.

Table 3 further demonstrates that pond area positively influenced aquaculture fish production at the 5% significance level with a predicted value of

0.132. This finding indicates that a one-hectare increase in pond area has contributed to an improvement in the production of fish aquaculture 0.132 ton, *ceteris paribus*. It is widely known that pond is the avenue where the fish raises, without the availability of sufficient pond area, the production process of fish aquaculture would not be successful. Put differently, pond area is the main factor contributing towards an increase in aquaculture fish production. A large number of unused lands for the fish pond in the South Aceh Regency requires more attention from the government to be converted into pond fisheries. Abundant unused land in the regency is very potential and suitable to be converted to and development becoming fish pond aquaculture area.

Our finding of the significant positive impact of pond area on aquaculture fish production is supported by many previous types of research findings. For instance, Negara *et al.* (2017) recorded a significant positive effect of the fish pond on catfish production in Denpasar City, Indonesia. In addition, research conducted in India by Palash *et al.* (2018) also found that the conversion of land to pond cultivation has led to an increase in fish production. In Oyo City, Nigeria, Tunde *et al.* (2015)

found that pond fishery production increased significantly due to the availability of sufficient land area for fish cultivation. Lastly, Musuka and Musonda (2012) also proved that extensive land use has contributed to promoting the production of fish aquaculture in the region of Caribbean lake, Zambia.

Besides, Table 3 illustrates an insignificant influence of fish nurseries on aquaculture fish production in the district. The results of this study further signify that the fish seeds had no contribution towards an increase in the production of fish aquaculture. This is because although the number of seeds available is more than sufficient but having no support of sufficient fish feedings, pond area, and good quality of water, the addition of only fish seeds would not be able to contribute towards an improved aquaculture fish production. If the presence of fish feeds is insufficient, the fish would prey on each other and cause fish to die. Similarly, if more fish seeds are put into a limited area of the pond would result in fish density, fish unhealthy, and, finally, cause fish death. Lastly, bad water quality, such as inappropriate power of water hydrogen (Ph), conditions of melted oxygen and carbon dioxide, various organic loads have worsened fish healthiness and, these unexpected conditions would ultimately, lead to fish mortality (Zeitoun and Mehana, 2014; Demeke and Tassew, 2016).

Our empirical findings indicate the importance of adjusting the number of fish seeds poured into the pond must be appropriate and proportional to the land area, supported by sufficient fish feeding, and meet minimum nutritional needs of fish, as well as the good fish pond water quality according to the type of fish. Failure to meet these conditions, thus, it is no point to pour more fish fry into the limited fish pond area. In this perspective, the government's role through the Department of Marine Affairs and Fisheries in the regions is very important in providing training related to fish farming and handling.

Our empirical evidence related to the insignificant effect of the fish seeds on aquaculture fish production is in harmony with the empirical findings of previous research performed by Fahrudin (2018) in the district of Tugu, Semarang, Indonesia. The raise of fish seeds should be supported by the utilization of appropriate feeds and fish drugs to maintain the healthy seeds, to avoid unnecessary conditions causing fish death. The health of fish seeds, breeding dexterity, and quality of pond water determined fry mortality rates and, in turn, mainly determined aquaculture fish production (George *et al.*, 2010; Bisht *et al.*, 2013;). Sihag and Sharma (2012); Pagrut *et al.*, 2017; Banerjee and Ray, 2017) also recorded that the fish seeds raised in the pond with bad water quality have caused fish health problems and the mortality rate of freshwater fish and brackish and, ultimately, have lowered the aquaculture fish production level.

Referring to Table 3, the study also recorded that the existence of fishermen had contributed towards improving aquaculture fish production in the South Aceh Regency at the 1% level of significance with a predicted value of 0.221. This empirical result signifies that an increase in the number of workers by 100% has contributed to the improvement of production in fish aquaculture by 22.10%, *ceteris paribus*. The employment of proper, competent, professional, and resourceful manpower to handle fish aquaculture matters, such as affording fish bait, preserving good water quality conditions, ensuring fish ponds' sanitary, and guaranteeing good fish care are among the crucial efforts that need to be taken to ensure a continuous improvement in aquaculture fish production (Bisht *et al.*, 2013). The capability of workers to perform fish handling duties must be continuously enhanced by conducting relevant workshops and training so that the fishermen would be responsive to alterations in natural environments and the emergence of new-fangled sorts of fish malady. In responding to the unexpected

seasonal changes, supports from relevant authorities through the local and regional marine and fisheries services offices is highly needed in socializing professional handling of fish aquaculture cultivation through fish management training and workshops.

The existence of significant influence of the number of workers in improving aquaculture fish production in the regency is in parallel with the empirical results of earlier studies that documented a maximum fish production could be realized through utilizing a proportional and qualified number of fishermen (Ng'onga *et al.*, 2019). Sundari and Priyanto (2016) also documented evidence of the positive role of fishermen to enhance catfish production in the district of Tasikmalaya, West Java, Indonesia. The increase in aquaculture fish production contributes to an increase in revenues and profits of fishermen and, consequently, the fish farmers could further expand their fish business entities. The expansion of the aquaculture fish business unquestionably requires the new recruitments of workers. Consequently, this would surely support the economic development agenda by the government to reduce unemployment in the regions and nationwide (Sarjito *et al.*, 2015). Not only that, an improvement in aquaculture fish production implies an enhancement in the income of the fishermen and the new workers' recruitment that finally contributes to poverty eradication (Iruo *et al.*, 2018).

Last but not least, as reported in Table 3, the study found a positive influence of capital on aquaculture fish production with the forecasted value of 0.646 at the 1% level of significance. This empirical result signifies that a 100% increase in capital has contributed to a 64.60% increase in the production of fish aquaculture, *ceteris paribus*. Given the estimated coefficient magnitude, the factor of capital was documented to be the most crucial determinant in aquaculture fish production in the regency of South Aceh, Indonesia. Without having adequate

capital, the aquaculture fish business would go into bankruptcy (Elsner and Isphording, 2017). Capital is an essential input needed in all stages of the aquaculture fish production process, covering the initial expenses of providing pond fish area and its maintenance cost, purchasing fish seeds, fish foods, and medicines, ensuring water discharge, compensating workers with fair wages, etc. Thus, it is incredibly natural and normal that capital sufficiency is recorded as the most critical factor in determining the production of fish aquaculture businesses. Capital is the main contributor to the success in each stage of aquaculture fish production processes (Andayani, 2016).

Our empirical evidence of the significant positive effect of capital on aquaculture fish production is in harmony with many previous pieces of research (Osondu and Ijioma, 2015; Andayani, 2016; Fajriati *et al.*, 2018; Ebukiba and Anthony, 2019). For example, in their study in the Abia states, Nigeria, Osondu and Ijioma (2014) documented that the efficient use of available capital has helped farmers to increase their fish production to the maximum level. The existence of sufficient capital according to the needs of the production process of fish aquaculture is highly crucial in promoting fish production (Andayani, 2016). Similarly, Fajriati *et al.* (2018) who researched in Klaten Regency, Central Java, Indonesia found that efficient use of capital has contributed to an enhancement in aquaculture fish production. Finally, a study conducted in the state of Nassarawa, Nigeria by Ebukiba and Anthony (2019) also found that the availability of sufficient capital, which is supported by proficient capital management, had improved fish production.

On the whole, our empirical results imply that except for fish seeds, the existence of pond fish area, fishermen, and capital were among the significant contributors towards an improvement in aquaculture fish production in the South Aceh Regency. The study also recorded

that the availability of an adequate amount of capital is the most dominant factor in determining the improvement in aquaculture fish production. These empirical results further signify that fish farmers should ensure the availability of a sufficient amount of capital. This is the most common obstacle that persisted among the micro-and small-scale fish farmers business entity, which urgently calls for government financial supports. In this scenario, the government must assist financially fish farmers by offering soft loans.

The government should initiate coordination with national and local government-owned banking enterprises, such as Bank Syariah Indonesia (BSI) and Bank Aceh Syariah (BSA). Besides, In addition, the government is hoped to help to provide adequate pond area through a program of idle and vacant land conversion to fish ponds. As a final point, the government needs to conduct routine and continuous socialization and fish farming training, and relevant professional fish management workshops. All fish farmers should be given an open and equal opportunity to attend free of charge training and workshops agenda, initiated by the local and central government authorities under the supervision of the offices of Marine and Fisheries Services. The said fish aquaculture training and workshops are intended to improve fish farmers' skills and capability in responding to climate change and the appearance of new-franked fish diseases and illness and adapting those seasonal changes to minimize their adverse effects on fish health and fish mortality, and, finally, ensuring the improvement of aquaculture fish production.

CONCLUSION

This study found empirical evidence that pond size area, number of fish farmers, and amount of capital significantly and positively affected the aquaculture fish production in the South Aceh District, Aceh Province, Indonesia.

Meanwhile, the number of fish seeds was found to have an insignificant influence on the production of fish aquaculture. These empirical results indicated that the increase in aquaculture fish production must be supported by the provision of sufficient capital, pond area, and the number of fish farmers. Government support by offering soft loans, initiating a program for converting vacant land into fish ponds, and increasing the capacity of fish farmers are strategic steps in efforts to increase aquaculture production.

To enrich the obtainable empirical results, further studies on the theme are recommended to ponder the characteristics of fish farmers, natural, environmental, and macroeconomic aspects, such as fish species, natural and seasonal factors, types of diseases, fish market prices, number of competitors, cost of capital, regulations, and climate change. The use of a combination of time series and panel data by considering a longer study period and comparative analysis between cities and provinces will provide comprehensive empirical evidence regarding the determination to increase aquaculture production in Indonesia.

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