Analysis of production and input efficiency of tiger shrimp pond in Aceh Jaya district, Indonesia

Indra¹, Safrida¹, E Marsudi¹ and I Zikri¹

¹ Department of Agribusiness, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia

* E-mail: indrazainun@unsyiah.ac.id

Abstract. Shrimp pond is one of the main livelihoods of coastal communities in Aceh Jaya. However, its productivity is classified as very low. This study aims to (1) analyze the factors that influence shrimp pond production in Aceh Jaya, (2) analyze the allocative efficiency of input use in shrimp ponds, and (3) analyze the area of land under the break-even point condition of shrimp ponds. The method used in this study is a survey method. Sampling was done by a multistage random sampling technique with a sample of 40 farmers. Data were analyzed using the Cobb-Douglas production function model, Marginal Production Value and Marginal Costs, and the break-even point. The results showed that the pond area, number of shrimp seed, labor and fertilizer had a significant effect on tiger shrimp production. Variable land area and the number of seed are negatively correlated shrimp production, therefore both variables must be reduced because it is inefficient, while other variables are positively correlated with tiger shrimp production and are not efficient yet. In the future, to increase tiger shrimp production in the study area can be done by increasing the inputs that exist in the model except, land and shrimp feed. The cultivation of tiger prawns in the study area is quite profitable, the break event point production volume is 352.48 kg and the area of land is 0.37 hectares.

1. Introduction

Fishpond business is one of the main sources of livelihood of coastal communities, in addition to being a fisherman. The commodities cultivated in the pond are tiger shrimp and white shrimp which have high economic value [1]. If the average productivity of black tiger shrimp farms is 2 tons/ha and the domestic selling price is Rp180 thousand / kg [2], then the total income of farmers (pond farmers) is Rp.340 million. If the production cost per kg of shrimp is IDR 24,000 [3], then the net receipts of tiger shrimp farming are around IDR 292,000,000 per hectare. The benefits are almost the same if the pond farmers cultivate white shrimp. The meaning is that the cultivators or tiger shrimp farms farmers in Aceh will be rich and prosperous.

In fact, in the existing conditions of shrimp farmers (pond farmers) in Aceh in general and in Aceh Jaya in particular, most are still classified as poor. According to [4] the poverty rate in Aceh Jaya in 2016 was 15.01 percent, the number of underprivileged families was 1,838 households and was mostly concentrated in the Krueng Sabee, Sampoiniet, Jaya, and Teunom Districts. It was further stated that of the percentage of the poor population, more than 70 percent were in rural areas with main livelihoods as farmers and fishermen (RPJMK Aceh Jaya 2012 - 2017).
The low income of aquaculture fishermen (ponds) is due to the productivity of ponds in Aceh Jaya in 2016 which is very low, which is only 0.10 tons/ha and this is the lowest pond productivity in Aceh Province [5]. The area of ponds in Aceh Jaya in that year was 294.8 ha with a production of 30 tons. In the same year, the level of added productivity in Aceh was 0.92 tons/ha and national pond productivity reached 3.49 tons/ha [6].

To find out and analyze the contributing factors that cause the low productivity of shrimp ponds in Aceh Jaya, it is necessary to conduct scientific research. This study attempts to analyze how much the efficiency of using production inputs, and to examine the area of land that must be cultivated by farmers in the break event point of the shrimp pond business. The purpose of this study is to: (1) analyze what factors influence tiger shrimp pond production in Aceh Jaya, (2) analyze the allocative efficiency of input used in shrimp pond businesses, (3) examine the size of pond in a break-even point condition.

2. Material and Methods
This research uses survey methods and quantitative approaches. Primary data were obtained from field observations and interviews with respondents. Secondary data were obtained from relevant agencies, Statistical office (BPS), the Office of the Panglima Laot (the local institution for sea and fisheries).

2.1 Population and Sample
The population was all shrimp farmers in Aceh Jaya. Sampling was done by multistage random sampling. Two sub-districts have been selected from a total of 5 sub-districts, namely Jaya and Indra Jaya. Then two villages have been chosen from each selected sub-district. It assumes that the characteristics of the population are homogeneous, and 10 farmers from each village are selected as samples. Thus the total sample is 40 households.

2.2 Data Analyzing
The production estimation model used in this study is the Cobb-Douglas production function. This model was chosen because some of the advantages include the estimation of the line. This function will produce a regression coefficient, which also shows the elasticity value of each relevant independent variable and the amount of elasticity while simultaneously showing the level of returns to scale [7][8][9]. Mathematically the form of Cobb-Douglas production function can be written as follows [10][7]:

$$ Y = b_0 X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} $$

where:
- $Y$ = tiger shrimp production (kg)
- $X_1$ = pond area (ha)
- $X_2$ = number of shrimp seed (tail)
- $X_3$ = amount of feed (kg)
- $X_4$ = amount of fertilizer (kg)
- $X_5$ = human labor (HKP)
- $X_6$ = pesticides (liters)
- $b_0$ = constant
- $b_1$ - $b_6$ = parameters to be expected

The next step is to conduct statistical tests, which are t-test, F-test and coefficient determinant test. To analyze the allocative efficiency of the use of production factors, an approach to the allocation of efficiency factors of production (Ki) using the formula [11]:

$$ K_i = \frac{b_i y p_y}{X_i p x_i} = \frac{\text{Marginal Production Value (MPV)}}{\text{Marginal Production Cost (MPC)}} $$

2
where:
\( b_i \) = elasticity of factor production;
\( y \) = average production (output);
\( p_y \) = average output price;
\( x_i \) = average of production factor, and
\( px_i \) = average price of production factor.

If the value of \( K_i = 1 \), it implies that the use of production factors is efficient; if \( K_i < 1 \) means that the use of inputs is not efficient; and if \( K_i > 1 \) means that the use of inputs is not efficient yet. To assess the area of a pond in a break-even point (BEP) condition, a break-even approach [12] is applied:

\[
\text{BEP of production volume} = \frac{\text{Total Production Costs}}{\text{Selling Price of Shrimp}}
\]

(3)

\[
\text{BEP of production price} = \frac{\text{Total Production Cost}}{\text{Total Production}}
\]

(4)

\[
\text{BEP of land pond scale} = \frac{\text{BEP of production volume}}{\text{Total production/hectare}}
\]

(5)

3. Results and Discussion

3.1 Model of Production Function

The results of the estimation of the production function using the Cobb-Douglas function in equation (1) are as follows:

\[
Y = 8416.93 \times 1.275 X_1 \times 1.271 X_2 \times 1.528 X_3 \times 0.557 X_4 \times 1.658 X_5 \times 0.305
\]

eq. (1)

where:
* Significant
** Highly significant
ns Not significant

The test results show that Sig F = 0.000 <α0.05 then accepts the hypothesis Ha reject H0. This means that variables \( X_1, X_2, X_3, X_4, X_5, \) and \( X_6 \) simultaneously have a significant effect on tiger shrimp production in Aceh Jaya. Furthermore, the partial test results show that the land area variable \( (X_1) \) has a very significant effect (negatively) on tiger shrimp production. Every additional pond area \( (X_1) \) of 1%, will cause a decrease in tiger shrimp production by 1.275%. This shows that the variable land area is no longer a determining factor in increasing tiger shrimp production. Increasing the area of land will cause increased capital and this is a problem for farmers because on average they have very limited capital. At a practical scale, the land is an essential capital in production and asserting the need for applying the efficiency of other production capitals in a farming system [13][14][15][16]. The results of interviews with respondents showed that farmers did not focus on running a pond farming business, limited experience and knowledge, lack of business capital, and poor business management.

The shrimp seed variable \( (X_2) \) significantly (negatively) on tiger shrimp production. Each additional amount of shrimp seed \( (X_2) \) of 1%, will cause a decrease in tiger shrimp production by 1.271%. The decline in tiger shrimp production is due to the increase of shrimp seed, causing the density of shrimp seed in ponds to be high, resulting in competition for food. As a result, often sores become sick and die. The low shrimp seed quality also greatly affects tiger shrimp production.

The shrimp feed variable \( (X_3) \) has a positive effect on tiger shrimp production, but the effect is not significant. Each additional amount of feed \( (X_3) \) of 1%, will cause an increase in tiger shrimp
production by 1.528%. There are 2 possible reasons why the amount of feed does not significantly affect the production of tiger shrimp, namely (1) the condition of the ponds in the study location is still quite fertile as seen from the color of the water in the brownish-green pond and this shows that the water in the pond is filled with moss that can become shrimp food especially in the period 0 - 30 days after planting, and (2) it is likely due to the poor quality of the shrimp seed, so that even though they are given a lot of food they are not responded well by the shrimp or shrimp.

The man labor variable ($X_4$) significantly (positively) influences the production of tiger shrimp. Every additional workforce ($X_4$) of 1%, it will cause an increase in tiger shrimp production by 0.557%. This is consistent with the previous explanation that often the farmers do not focus or do not make pond farming a priority, but instead, some of them consider this business as a side income so that the time devoted to managing the pond is relatively small.

The fertilizer variable ($X_5$) has a very significant effect (positively) on tiger shrimp production. Each addition of fertilizer ($X_5$) by 1%, it will cause an increase in tiger shrimp production by 1.658%. This shows that the use of fertilizer is still relatively limited due to the limited capital of farmers and this fertilizer business has been able to increase the fertility of water in ponds. As a result of an increase in the number of mosses so that there is food for fries and tiger prawns in the study area.

The pesticide variable ($X_6$) has a positive effect on tiger shrimp production, although the effect is not significant. Every increase of pesticide ($X_6$) by 1%, it will cause an increase in tiger shrimp production by 0.395%. This means that the increase in tiger shrimp production in the study area of 89.8% is determined by $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, and $X_6$. While another 10.2% is explained by other variables outside the model. It is evident that the use of smaller units would decrease the large amount of inputs to increase productivity, while shrimp farmers often cannot afford such costly investment [17].

### 3.2. Input Efficiency

To calculate the economic efficiency used the efficiency approach to the allocation of production inputs (formula 3). The results of the calculations are shown in Table 1.

**Table 1. Allocative efficiency of input in tiger prawn pond production**

| Input              | MPC          | MPV                  | $K_i$  | Remarks          |
|--------------------|--------------|----------------------|--------|------------------|
| Shrimp pond area   | 3,470,268.00 | (101,337,959.22)     | -29.20 | not efficient    |
| Shrimp seed        | 50.00        | (1,369.48)           | -27.39 | not efficient    |
| Feed               | 17,500.00    | 289,025.66           | 16.52  | not efficient yet|
| Man labor          | 100,000.00   | 279,292.68           | 2.79   | not efficient yet|
| Fertilizer         | 2,550.00     | 424,470.58           | 166.46 | not efficient yet|
| Pesticides         | 9,000.00     | 418,406.26           | 46.49  | not efficient yet|

Based on Table 1, it can be seen that marginal production and efficiency levels for feed variables, labor, fertilizer, pesticides, and pesticides are positive. This means that shrimp production in the study area can increase by adding each unit of production input. On the other hand, for the variable area of ponds and shrimp seed, the negative mark. This means that both inputs are already inefficient and do not need to be added anymore and can even be reduced to achieve efficiency. The table also shows that there is no efficiency level of 1, which means that there is no efficient use of inputs.

### 3.3. Break-even Point Analysis

The break-even point referred to in this study consists of the break-even point of production volume and the break-even point of the land area both concerning profits and poverty. The break-even point of production volume is calculated as follows:
BEP of production volume = \frac{\text{Total Production Costs}}{\text{Selling Price of Shrimp}} = \frac{\text{Rp29,370,575}}{\text{Rp83,324/kg}} = 352.48 \text{ kg}

This means that in the production volume of 352.48 kg of shrimp, the farmer economically in the study area does not benefit. The amount of revenue obtained is only able to cover the cost of pond production. In this condition, it is called the break-even point. If the pond production of the farmer is below 352.48 kg, then they will suffer losses. The results showed that the production volume of shrimp ponds in the study area was 1,017 kg/farmer or 953.85 kg/ha. This shows that shrimp farming is very profitable. Then the break-even point of production value and the break-even area is calculated as follows:

BEP of production price = \frac{\text{Total Production Cost}}{\text{Total Production}} = \frac{\text{Rp29,370,575}}{1,017 \text{ Kg}} = \text{Rp28,880/kg}

BEP of land pond scale = \frac{\text{BEP of production volume}}{\text{Total production/hectare}} = \frac{352.48 \text{ kg}}{953.85 \text{ kg/ha}} = 0.37 \text{ ha}

The calculation results above show that the cost of returning the main point of production is IDR 28,880/kg. This means that if the farmer farms sell shrimp at a price of IDR 28,880/kg, they will not get any business profit because their business can only cover the cost of production. Furthermore, if they sell below that price, they will suffer losses and vice versa if they sell above that price, they will get a profit. The results showed that the price of shrimp at the time of research at the study site was IDR 83,324/kg, meaning that shrimp pond farmers in the study area received adequate profits.

Furthermore, the main point of return for the land area is 0.37 ha. This means that to obtain a normal profit, the pond farmer must cultivate shrimp on land above 0.37 ha. The results showed that the average area of ponds per sample farmer was 1.07 ha or above the breakeven area. This means that in terms of the area of land, the pond business in the study area is quite profitable. In terms of cost investment and profitability, the shrimp farming strong-minded by scale, inputs and technology application used [18][19].

The Aceh Jaya Regency Poverty Line (GK) in 2016 is IDR331,940/capita/month. If the average number of household members (family) in the study area is 4 people, then the total family income in a month to get out of poverty or to not be included in the poor category is a minimum of IDR 1,327,760. The results showed that the average profitability of shrimp ponds in the 2018 study area was IDR 54,867,043 per farmer per harvest period. If the figure is divided by the shrimp harvest period of 6 months, the monthly profit or income is IDR 9,144,507. This value indicates that shrimp pond farmers in the area are not classified as poor, with a note that their shrimp farming business has not failed in harvest [20]. However, in practice that raising shrimp is a high-risk business because it does not rule out the shrimp being exposed to diseases or viruses and causing crop failure. If this happens, the shrimp farmers will experience a total loss that is as much as investment or production costs incurred, reaching Rp39 million per hectare.

As mentioned above, the break-even area of ponds was 0.37 ha. That is, in existing conditions with traditional technology, farmers do not obtain normal profits. Furthermore, for farmers to obtain a net
profit above the poverty line so that they are not classified as poor, they must work at a minimum of 0.53 hectares of fishponds. However, if pond cultivation technology can be upgraded to a better stage, then the area of ponds needed to meet the needs of households that are not classified as poor will become even smaller.

4. Conclusions
All variables in the model simultaneously (together) significantly affect the production of tiger shrimp in the study area. However, partially, only the variable number of feed and pesticides had no significant effect, while the other variables all had a significant effect on tiger shrimp production in the study area. Input land area and amount of shrimp seed use in tiger shrimp ponds in the study area are already inefficient, meaning that these two variables in the future must be reduced. While other inputs (feed, labor, fertilizer, and pesticides) are still inefficient, meaning that these inputs can still be increased. BEP production volume of tiger shrimp farming in the study area is 352.48 kg, BEP production value of IDR 28,880/kg and the break-even point for land area is 0.37 ha. The tiger shrimp farming business in the study area provides a decent production value of IDR 9,144,507/capita/month or IDR 1,327,760/household, the family of tiger shrimp farmers in the study area is not classified as poor, assuming shrimp ponds are not attacked by diseases or viruses. Furthermore, so that tiger shrimp farmers are not classified as poor, then they must manage ponds of at least 0.53 hectares.

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