Risk analysis of polyculture cultivations of tiger shrimp (*Penaeus monodon*) and tilapia (*Oreochromis niloticus*) (case: Belawan Sicanang Village, Medan Belawan District, Medan City)

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Abstract. This study aims to analyse the level of income received by Belawan Sicanang sub-district farmers in cultivating tiger shrimp and tilapia polyculture and to analyse the risk of production, price risk, income risk and risk mitigation. The sampling method used was the snowball method. The sample size was 40 respondents. The results of the study found that the average income per hectare per tiger shrimp cultivation and tilapia cultivation was IDR 7,947,489,525. The coefficient of variation (CV) of income is 0.304; production of 0.38 for tiger shrimp and 0.44 for tilapia and the price of 0.11 for tiger shrimp and 0.04 for commodity tilapia. The polyculture culture of tiger shrimp and tilapia in the study area has a level of risk and is feasible to continue. To reduce the risk, risk mitigation is carried out, namely: ex ante by taking loss prevention measures, interactive by improving the cultivation system, ex-post by strengthening the joint group of fisheries in the research area.

1. Introduction

Aquaculture has become a sector that makes a major contribution to the national economy. On the other hand, the domestic market is still very open and continues to grow for various aquaculture commodities. The contribution of the fisheries sector has been proven by the increasing level of foreign exchange earnings. In line with the expansion of cultivation activities and demand for fishery products, aquaculture activities were developed in the early 1980s [1].

Table 1 explains that the average value of shrimp exports in 2014 and 2015 shows the largest value in Indonesian fishery commodity exports compared to other fishery export products, which is 43.83%. One of the shrimp ponds that has good business prospects for development is tiger prawn cultivation. Based on data from the Food and Agriculture Organization, it is stated that the need for fish for the world market until 2010 is still experiencing a supply shortage of two million tons / year [2].

Table 2. explains that from 2009 to 2012 the development of tilapia production in North Sumatra increased, where in 2009 it was 39,614 tons and in 2012 it was 65,951 tons. The development of tilapia cultivation technology on the other hand is running very slowly, but tilapia remains the most produced and consumed cultivated commodity in Indonesia. Shrimp farming is more profitable than tilapia, because the selling price of shrimp is higher. Anticipating that shrimp farming activities will continue, it is necessary to apply poly-culture cultivation. Polyculture is a cultivation method used for...
the maintenance of multiple products in one field. This system incised benefits, namely a high level of land productivity.

| Commodity                  | Year       | Contribution to Exports Average Total (%) |
|----------------------------|------------|------------------------------------------|
| Shrimp                     | 1,743,452,232 | 1,370,466,390                          | 43.83                   |
| Tuna, Tongkol, Skipjack    | 576,281,781 | 491,981,470                              | 15.04                   |
| Crab                       | 345,880,705 | 265,911,128                              | 8.61                    |
| Seaweed                    | 230,932,974 | 178,090,553                              | 5.76                    |
| Squid                      | 122,515,154 | 156,360,406                              | 3.92                    |
| Salmon                     | 42,781,645  | 68,731,060                               | 1.57                    |
| Other fisheries            | 770,181,501 | 741,544,302                              | 21.28                   |
| **Total**                  | **3,832,025,992** | **3,273,085,309**                      | **100.00**               |

Belawan Sicanang Village is a sub-district within Medan Belawan District, Medan City, North Sumatra Province as the largest fishery producer in North Sumatra. Every effort is aimed at making a profit, as well as for the polyculture pond farmers of tiger prawns and people's tilapia. However, every business is inseparable from possible risks that could cause big losses to business actors. This study aims to analyse the level of income received by Belawan Sicanang sub-district farmers in cultivating tiger shrimp and tilapia polyculture and to analyse the risk of production, price risk, income risk and risk mitigation.

2. Methods

2.1. Determination of the area and sample

Determination of the area is done purposely. The population in this study were farmers in Sicanang Village and who were cultivating the polyculture of tiger shrimp and tilapia. The sample size was 40 respondents. The sampling method used was the snowball sampling method. The data collected were primary and secondary data. Primary data obtained directly through interviews. Secondary data related
to the research were obtained from the Office of Marine Affairs and Fisheries of North Sumatra and other related agencies [5].

2.2. Data analysis
The cultivation income of tiger shrimp and tilapia polyculture for each harvest period is analysed using income calculation ($\pi$) [6]. The following formula is used:

$$\pi_{1,2} = TR_{1,2} - TC_{1,2} \pi_{1,2} = Y_1 PY_1 + Y_2 PY_2 - \sum X_{1,2} PX_{1,2} - BTT_{1,2}$$  \hspace{1cm} (1)

Descriptions:
- $\pi_{1,2}$ = Income from tiger shrimp and tilapia polyculture farming (IDR)
- $TR_1,2$ = Total acceptance of tiger shrimp and tilapia polyculture
- $TC_1,2$ = Total expenditures for tiger shrimp and tilapia polyculture
- $Y_1$ = Tiger shrimp production (Kg)
- $PY_1$ = The unit price of tiger shrimp (IDR / Kg)
- $X_{1,2}$ = Polyculture production factors (variable)
- $PX_{1,2}$ = Polyculture production factors price (IDR / unit)
- $BTT_{1,2}$ = Total fixed cost of polyculture (IDR)
- $Y_2$ = Tilapia production (Kg)
- $PY_2$ = Tilapia unit price (IDR / Kg)

Production risk, price risk, and income risk for the polyculture culture of Tiger Shrimp (*Penaeus monodon*) and Tilapia (*Oreochromis niloticus*) using the calculation of risk of variance, standard deviation and coefficient of variation [7]. Variance formula measures are as follows:

$$V^2 = \frac{\sum_{i=1}^{n}(\epsilon_i - \overline{\epsilon})^2}{n-1}$$  \hspace{1cm} (2)

Standard deviation is the root of variety, or which is mathematically formulated as follows:

$$V = \sqrt{V^2}$$  \hspace{1cm} (3)

Where:
- $V^2$ = Variance
- $V$ = Standard deviation
- $\epsilon$ = Average production yield (kg / ha), average price (IDR / kg), average farm income (IDR / kg).
- $\epsilon_i$ = Production yield (kg / ha), price (IDR / kg), income (IDR / kg) cultivation
- $n$ = Number of farmer samples

The coefficient of variation or the lowest risk level is the ratio between the risk that must be borne by the farmer and the amount of income that will be obtained as a result of the amount of capital invested in the production process [7].

$$CV = \frac{V}{\pi}$$  \hspace{1cm} (4)

Where:
- $CV$ = Coefficient of variation
- $V$ = Standard deviation
- $\pi$ = Average revenue (kg / ha), average price (IDR / kg), farm income - average (IDR / kg).
The feasibility of cultivating tiger prawns and tilapia polyculture was analysed using a mathematical calculation of the risk lower limit of the highest yield [7]. The determination of the lower limit is formulated as follows:

\[ L = E - 2V \]  

Information:
L = Lower limit of production, price and profit
V = Standard deviation (standard deviation)
E = Average yield (kg / ha), average price (IDR / kg), average cultivation income (IDR / kg).
If a. L > 0, then the farmer will not experience any loss of production; b. L < 0, then the farmer experiences a loss for each production.

3. Results and discussion

3.1. Production costs, receipts and income of polyculture cultivation of tiger shrimp and tilapia

The average value of total costs, revenues, and incomes were using per farmer's land area and per hectare in Polyculture of Tiger Shrimp and Tilapia can be seen in Table 3.

| Descriptions                  | Per Farmer (ton) | Per Hectare (ton) |
|-------------------------------|------------------|-------------------|
| Production cost               | 5,064,157.23     | 4,825,185.99      |
| Price of Tiger Shrimp         | 88,375.00        | 88,375.00         |
| Tiger Shrimp Production       | 61.41            | 48.00             |
| Price of Tilapia              | 18,025.00        | 18,025.00         |
| Tilapia Production            | 45.53            | 39.33             |
| Fishing pond reception        | 8,975,000.00     | 7,859,499.00      |
| Total Receipts                | 15,323,662.50    | 12,773,035.50     |
| Total Income                  | 10,259,505.80    | 7,947,849.52      |

Table 3. explains that the income per farmer is IDR 10,233,846.97/production and the income per hectare is IDR 7,947,849.52/production. The income received by farmers is positive because the income is greater than the total cost to be borne by the poly-culture farmer. The biggest income earned by farmers is income from fishing ponds. Fishing pond income per farmer is IDR 8,975,000.00/production and income per hectare is IDR 7,859,499.00/production.

3.2. Risk analysis of polyculture cultivation of tiger shrimp and tilapia

The value of the risk variation coefficient means that the greater the value, the greater the risk faced, and vice versa. Standard deviation in risk means the large spread of risk that occurs in polyculture cultivation. The greater the standard deviation, the greater the spread of risk.

Table 4. shows that the highest risk in general is the risk of production with a coefficient of variation of 0.44 for tilapia and 0.38 for tiger shrimp, meaning that every 100 kg of tiger prawn production results in a risk of 44 kg and every 100 kg of tilapia production results in a risk of 38 kg. This is due to the low level of living of the commodity, especially tiger shrimp, which is only 15-20%. The income risk is 0.304 where the level of income is highly dependent on the risk of production and the price of the poly-culture commodity, which means that every IDR 100 of income from the cultivation of tiger shrimp and tilapia produces a risk of IDR 30.4. The price risk is 0.11 for the tiger...
shrimp commodity and 0.04 for the tilapia commodity, meaning that every IDR 100 the price of tiger shrimp results in a risk of IDR 11 and every IDR 100 the price of tilapia results in a risk of IDR 4.

Table 4. Production, price, and income risks of polyculture cultivation of tiger shrimp and tilapia in Belawan Sicanang Village, Medan City.

| Descriptions | Tiger shrimp | Tilapia |
|--------------|--------------|---------|
| Average Production (Qi) | 48.00 | 39.33 |
| Variety (v²) | 337.43 | 307.91 |
| Standard Deviation (v) | 18.36 | 17.54 |
| Coefficient of Variation (CV) | 0.38 | 0.44 |
| Price Risk | | |
| Average price (Qi) | 88,375.00 | 18,025.00 |
| Variety (v²) | 101,778.85 | 742,948.70 |
| Standard Deviation (v) | 10,888.55 | 861.94 |
| Coefficient of Variation (CV) | 0.11 | 0.04 |
| Income Risk | | |
| Income Risk | 7,947,849.525 | |
| Variety (v²) | 5,867,672,794,630.000 | |
| Standard Deviation (v) | 2,422,327.970 | |
| Coefficient of Variation (CV) | 0.304 | |

3.3. Lower limit of highest results
To measure the feasibility of cultivation, it can be seen from the lower limit of the highest yield, where if the average value of production, price and income exceeds the lower limit value, then the cultivation can be declared feasible to face risks.

Table 5. Lower boundary of tiger shrimp and tilapia polyculture cultivation in Belawan Sicanang Village, Medan City.

| Descriptions | Tiger shrimp | Tilapia |
|--------------|--------------|---------|
| Lower Boundary (L) | 11.26 | 4.24 |
| Price Risk | | |
| Lower Boundary (L) | 68,197.89 | 16,301.11 |
| Income Risk | | |
| Lower Boundary (L) | 3,103,193.585 | |

Table 5. shows that the lower boundary (L) for the risk of production per hectare is 11.26 kg for tiger shrimp and 4.24 kg for tilapia. In the production of polyculture cultivation, the lowest amount of production that can be produced for commodity tiger shrimp is 11.26 kg / ha / production while the commodity production of tilapia is 4.24 kg / ha / production. The lower boundary (L) for price risk is IDR 68,197.89 / kg for tiger shrimp commodity and IDR 16,301.11 / kg for tilapia commodity. The lower boundary of the highest yield (L) for the risk of income is IDR 3,103,193.585 / ha / production and the average income for polyculture cultivation of tiger shrimp and tilapia is IDR 7,947,849.525 / ha / production, meaning that cultivation in the research area is always experienced a profit with a minimum profit of IDR 3,103,193.585 / ha / production.
3.4. Risk mitigation for polyculture cultivations of tiger shrimp and tilapia

The ex-ante strategy is a risk before a shock occurs. It is designed to prepare the farm so that it is not too vulnerable when a shock occurs. Some actions such as making nets in the ponds so that when the commodities do not come out of the pond, spreading shrimp fries before tilapia for 1-2 weeks prevents tilapia commodities from eating tiger shrimp. Sell the produce to the agent after the harvest time arrives to reduce the depreciation of commodity weight, incurred transportation costs, ice costs and other costs. Adding additional commodities such as crabs so that farmers can still get daily income.

Interactive strategy is the response of farmers when a risk, this response involves reallocating resources so that the impact of risk on production can be minimized. When there is a high tide by making a wind dam, which is land which is piled into small pieces on the edge of the pond to reduce strength and rapid erosion on the edge of the pond. Selling a commodity when prices are rising or demand is high, in this case, what month to start cultivation really affects. In addition, by selling commodities directly to the market in retail

The ex-post strategy is a strategy carried out by farmers after a risk has occurred. This strategy aims to minimize the subsequent impact. This strategy depends on the status of the cultivation concerned in relation to sources of income and assistance from other parties. Strengthening the combined fisheries groups’ institution is needed so that there is cash to help capitalize farmers in the research area due to the cultivation of ponds, in this case increasing the status of ponds from traditional to semi-intensive so that the income of farmers can also increase in the future.

4. Conclusions

Average income per hectare per production is IDR 7,947,489.525. Income risk with a coefficient of variation (CV) of 0.304 is influenced by production risk with a coefficient of variation of (CV) of 0.38 for tiger shrimp and 0.44 for tilapia and is influenced by the coefficient of variation (CV) of 0.11 for tiger shrimp commodity and the coefficient of variation (CV) of 0.04 for tilapia commodity. Polyculture cultivation of tiger shrimp and tilapia is profitable in terms of production, price and income. In order to reduce the level production risk, price and income, efforts are made to mitigate risks. These efforts include: ex-ante by taking loss prevention measures and adding commodities to increase income, interactive by improving the cultivation and post-ante management system by strengthening combined fisheries groups in the research area.

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**Acknowledgements**
Thank you to all parties who have supported this research, Directorate General of Directorate General of Aquaculture, and residents of Belawan Sicanang Village.