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An Analysis of Shrimp Aquaculture Techniques In Secanggang District, Langkat Regency, Sumatera Utara Province

Anisa Rahmadhayani[1], Zulkifli Nasution[2], Agus Purwoko[3]

[1]*Regional and Rural Planning Study Program, Postgraduate School, Universitas Sumatera Utara, Medan, 20155, Indonesia*
[2]*Department of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan, 20155, Indonesia*
[3]*Faculty of Forestry, Universitas Sumatera Utara, Medan, 20155, Indonesia*

Abstract. *Aquaculture is an industry that has a tremendous opportunity. Indonesia's aquaculture prospects are rising. Langkat Regency is a region in Sumatera Utara Province located in the East Coastal Region with good options for brackish water aquaculture. There are four goals in this study. This study aimed to analyze the distribution of shrimp aqua farm locations in the Secanggang District, investigate the type of shrimp aquaculture in the district, analyze the economic aspects of shrimp aquaculture in Secanggang District and study the optimal aquaculture strategy as a priority for developing coastal areas in Secanggang District. This study uses a quantitative approach to conduct a descriptive study. Three steps are applied to analyze the data: Regional distribution, economic, and analytical hierarchy. The study shows that the aqua farms in Secanggang District are located in the production area, converted forest area, wildlife nature reserve, and production forest. There are four types of Shrimp aquaculture in Secanggang District: intensive, semi-intensive, traditional, and natural/organic. The study also shows the economic analysis of costs, income, and the efficiency of R/C ratios per cycle on four types of aquaculture. This study also indicates that shrimp aquaculture using the intensive technique is the most appropriate and priority for shrimp aqua farming development in Secanggang District.*

Keywords: *cooperative perfomance, modernization, people's economic condition*

Abstrak. Tambak merupakan industri yang memiliki peluang yang sangat besar. Saat ini, prospek budidaya perikanan Indonesia sedang meningkat. Kabupaten Langkat merupakan salah satu wilayah di Provinsi Sumatera Utara yang terletak di Wilayah Pesisir Timur dengan prospek budidaya perikanan air payau yang cukup baik. Penelitian ini bertujuan untuk menganalisis sebaran lokasi budidaya udang di Kecamatan Secanggang, mengetahui jenis budidaya udang di kabupaten tersebut, untuk menganalisis aspek ekonomi budidaya udang di Kecamatan Secanggang dan mengkaji strategi budidaya yang optimal sebagai prioritas pengembangan kawasan pesisir di Kecamatan Secanggang. Penelitian ini menggunakan pendekatan kuantitatif dengan melakukan penelitian deskriptif. Analisis data dilakukan dengan tiga tahapan : Analisis sebaran wilayah, analisis ekonomi dan Analitycal Hierarchy Process (AHP). Hasil penelitian menunjukkan bahwa budidaya perikanan di Kecamatan Secanggang terletak di kawasan produksi, kawasan hutan konversi, suaka alam satwa, dan hutan produksi. Ada empat jenis budidaya udang di Kecamatan Secanggang: intensif, semi intensif, tradisional, dan alami/organik. Studi ini juga menunjukkan analisis ekonomi biaya, pendapatan, dan efisiensi rasio R/C per siklus pada empat jenis budidaya. Penelitian ini juga

*Corresponding author at: Postgraduate School, Universitas Sumatera Utara, Jalan Prof. Mass, Medan 20155, Indonesia

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menunjukkan bahwa budidaya udang dengan teknik sistem intensif merupakan yang paling tepat dan prioritas untuk pengembangan budidaya udang di Kecamatan Secanggang.

Kata Kunci: AHP, Budidaya Perairan, Perikanan.

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1. Introduction

The marine and fisheries sector's development is a part of the national development of Indonesia. Therefore, it is essential to ensure the industries' sustainability [1]. Aquaculture is an industry that has a tremendous opportunity [2]. The aquaculture industry is an economic strategy that uses coastal resources. Coastal habitats can be divided into natural and artificial ecosystems based on their formation process. Natural ecosystems include mangrove, seagrass, and coral reef environments. Aquaculture, tidal rice fields, tourist destinations, industrial regions, and communities are examples of artificial ecosystems [3].

Currently, Indonesia's aquaculture prospects are rising. There are 2.8 million hectares of prospective aqua farming land in Indonesia, but only roughly 605,000 hectares have been utilized. These numbers indicate that approximately 2.19 million hectares of land along the Indonesian coast are still available for development [4].

Shrimp is a commodity with a high survival rate, rapid growth, high salt tolerance, and the ability to be produced with a high stocking density. The Vaname Shrimp (Litopaneus Vannamei) is one species that is easy to grow [5]. Shrimp aquaculture develops in fifteen provinces in Indonesia, including Sumatera Utara Province [6].

Langkat Regency is a region in Sumatera Utara Province located in the East Coastal Region with good prospects for catch fisheries, aquaculture (marine, brackish, freshwater), and fishery processing. One of the rising production in Langkat Regency comes from brackish water aquaculture. The primary commodities are shrimp, soka crab, and grouper fish. One of the nine coastal Districts in Langkat Regency that has potential is Secanggang District. The area's shrimp aquaculture provides enough to support the residents of Secanggang District's economy. Based on the regional spatial plan (RTRW), Secanggang District is a lowland coastal area at 4 meters above sea level, an excellent area for aquaculture activities to date.

Secanggang District was chosen as the location of this research. This area was determined deliberately with the consideration that shrimp is one of the leading commodities in the aquaculture sector in Langkat Regency. Secanggang District is the second largest shrimp production area in Langkat District, with Vaname and Windu commodities. In this district, there

are cultivation activities with various cultivation techniques, including Intensive, Semi-intensive, Traditional, and Natural/organic.

Aquaculture activities in Secanggang District are implemented by intense, semi-intensive, traditional, and organic techniques. The harvesting cycle varies between techniques. A harvest cycle lasts three months in intensive, semi-intensive, and traditional farming. For natural or organic methods, one cycle lasts four months, followed by a harvest every two weeks.

There are four goals in this study. This study aimed to analyze the distribution of shrimp aqua farm locations in the Secanggang District, investigate the type of shrimp aquaculture in the district, analyze the economic aspects of shrimp aquaculture in Secanggang District and study the optimal aquaculture strategy as a priority for developing coastal areas in Secanggang District.

2. Research Method

This study uses a quantitative approach to conduct a descriptive study. This study occurred in Langkat Regency's Secanggang from April to June 2021. The participants in this study were Secanggang District shrimp aqua farmers. The stratified random sampling method collected samples from up to 90 aqua farmers.

In this study, there are two categories of data: primary data and secondary data. Primary data was collected from vaname shrimp aqua farmers by direct observation in the field and direct interviews. Secondary data is gathered from publications, as well as from relevant parties or organizations.

Three steps are applied to analyze the data: Regional distribution, economic, and analytical hierarchy process. Regional distribution analysis was carried out to see the additional distribution and its suitability with the Langkat Regency Spatial Plan, especially Secanggang District. The second analysis is economic analysis The data is analyzed by recording and calculating the farmers' costs of aquaculture. The last analysis is the Analytical Hierarchy Process (AHP). The AHP approach is a decision-making strategy that assigns a value as a parameter to each criterion.

The first step in the analysis is regional distribution. The aquaculture area was digitized and analyzed using Google Maps images and Indonesian topographic maps. The goal of aqua farm

digitization is to provide a new layer for data analysis. The Langkat Regency Spatial Plan overlays the distribution of aqua farms.

The second step is the economic analysis of aquaculture. The analysis is carried out by quantitative analysis to determine the expenses and income. A business feasibility study was done by figuring out the R/C ratio with the following equation:

$$R/Crasio = \frac{Revenue\ (Rp)}{Cost\ (Rp)} \quad (1)$$

The following are the decision criteria used to evaluate the R/C ratio analysis results:

1.If the R/C ratio is > 1, the farm is profitable.

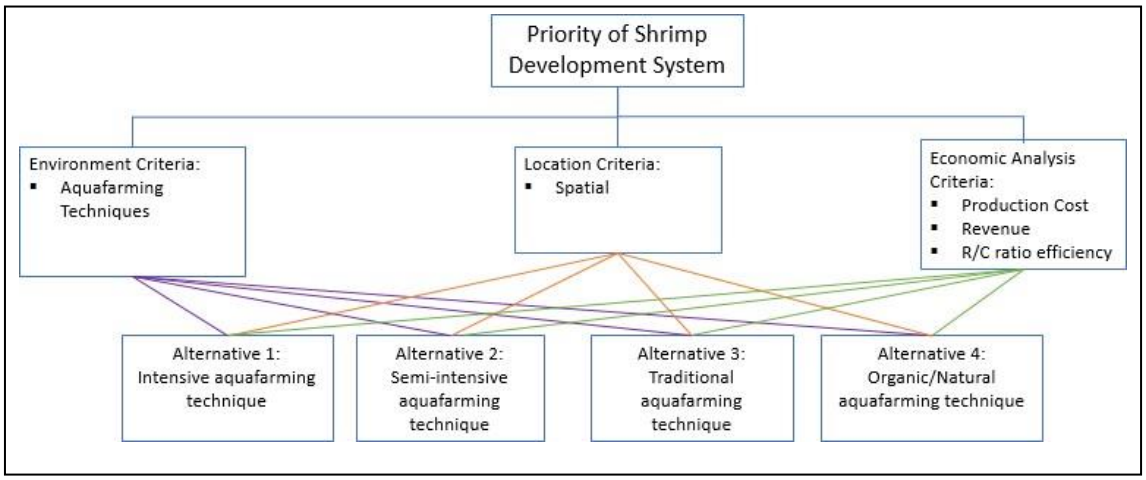
2.If the R/C ratio = 1, the farm is at break-even, meaning it does not generate a profit and does not lose money.

3.If the R/C ratio is < 1, the farm is losing money.

The next step is to test the difference between total costs and income. The tests were conducted to see significant changes in the overall cost and income of intensive, semi-intensive, traditional, and organic shrimp aqua farmers. The Kruskal-Wallis test was applied to two independent groups. The significance level for this difference test is 5% ($\alpha = 0.05$).

The next step is The Analytical Hierarchy Process (AHP). The AHP approach is a decision-making methodology that requires assigning a value to each criterion as its parameter in a process that comprises measures. To find alternate priorities for building shrimp aqua farming techniques by determining the level of influence of one parameter on other factors. There are four stages in this analysis: System identification, hierarchical structure, creating a pairwise comparison matrix, and creating an individual opinion matrix [7].

Priority analysis is used to determine a decision based on hierarchical/level criteria conditions. Before conducting the analysis, it is necessary to define the problem and the solution by determining the objectives, criteria, and alternatives. This analysis aims to establish the priority of cultivation technique development. This study's criteria include economic, locational, and environmental factors. Alternative aquaculture techniques include intensive, semi-intensive, conventional, and organic techniques. Problem identification is illustrated as a research hierarchy structure in Figure 1.



3. Result and Discussion

3.1. Regional Distribution of Shrimp Aquaculture Technique in Secanggang District

The regional spatial plan (RTRW) is a land-use planning tool. Based on the RTRW, Secanggang District is a lowland coastal area at 4 meters above sea level, an excellent area for aquaculture activities to date.

The production sector, including aquaculture, is regulated in article 52 of the Langkat Regency Spatial and Regional Planning (RTRW). It explains the zoning of spatial patterns for production and protected areas. The restriction of activities affecting and reducing the forest area is explained in paragraph 2 of Article 56. Aquaculture and other production activities that improve community welfare must carry out in areas designated for aqua farms.

Data on the distribution of aquacultures was generated using processed data from overlapping maps (RBI map, Village borders in 2019, RTRW of Langkat Regency in 2013-2033, and analysis of aquaculture production in 2020 by Marine and Fisheries Service of Langkat Regency). In Secanggang District, aqua farms total ± 1,521.12 ha, with intensive aquaculture covering 53 ha (3.48%), semi-intensive aquaculture covering 66.85 ha (4.39%), traditional aquaculture covering 995.26 ha (65.43%), and organic aquaculture covering 406 ha (26.69%).

Aquacultures are widespread in both productive and protected areas. They occupy 1142.96 hectares in the production area, both in residential and agricultural areas. Meanwhile, aqua farms were established in the nature reserve (313.75 ha) and production forests in the protected area. Aquaculture is spread over 7 villages; Tanjung Gading, Karang Gading, Selotong, Tanjung Ibus, Secanggang, and Hinai Kiri and Sei Ular. The distribution of aqua farms based on land use can be seen in the following figure.

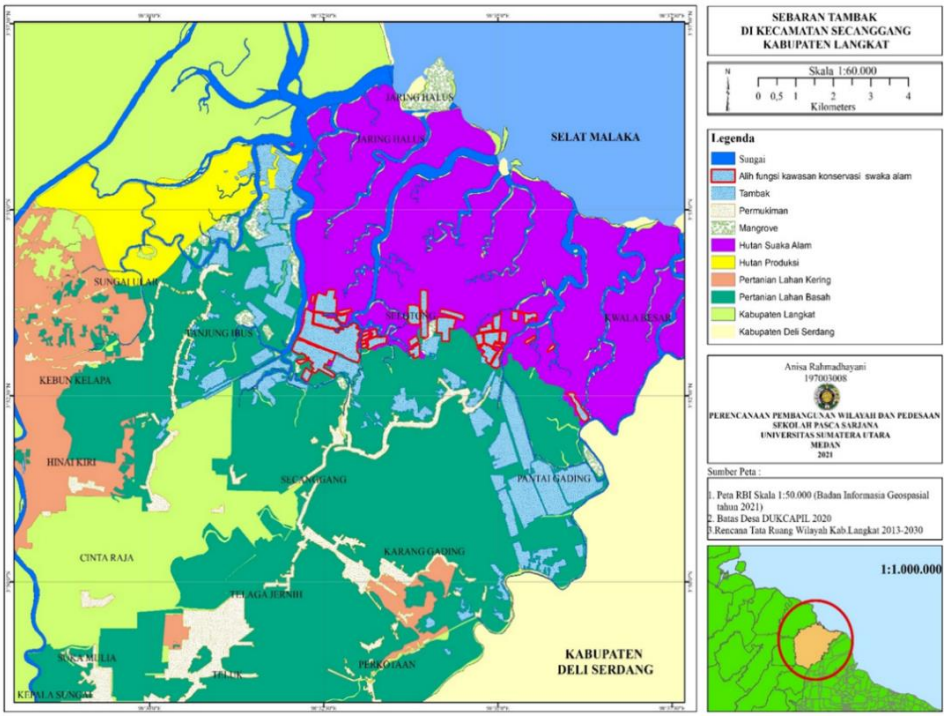


Figure 2. Distribution of Aqua farm locations in Secanggang District by Land Use

Based on the observations and interviews, shrimp aquaculture in Secanggang District are developing on a household scale. The aquaculture covers approximately 1-1000 m2 and employs semi-intensive to intensive aquaculture techniques, with a stocking density of 100-150 shrimp per m2. The following table shows the differences in technology and treatment acquired from the four shrimp aqua farm techniques in Secangang District:

Tabel 1. Shrimp Aquaculture Techniques in Secanggang District

No	Category	Natural (Organic)	Extensive Plus (traditional)	Semi- intensive	Intensive
1	Average land area (m^2)	31.667	3.740	945	778
2	Water source	Canal/River	Canal/River	Canal/Drilling well	Drilling well
3	Stocking density	1/m2	6/m2	60/m2	116/m2
4	Feed	-	Commercial and/or naturalfeed 2-3 times	Commercial 3-4 times/day	Pellets, 3-4 times/day
5	**Facilities**				
	Water Pump	-	-	Yes	Yes
	Long Arm	-	-	Yes	Yes
	Water Tank	-	-	Yes	Yes
	Waste Tank	-	-	-	Yes
6	Additional Commodities	Crab and Fish			
7	Aquaculture Standard Operational Procedure	25%	50%	75%	100%

There are variations between the four shrimp aqua farming techniques in Secanggang District, as shown in the table above. The management methods used in each type of aqua farm varied, including stocking density, feeding patterns, and water and environmental control techniques. Aquatic organisms, mainly fish, shrimp, and shellfish, are cultivated in aqua farms. The technologies utilized can also reveal differences in aquaculture techniques. The finding is in line with the expert's opinion, who stated that the density of economic distribution and demands, including feed, facilities, and infrastructure to support aquaculture activities, can show the level of technology for Vaname shrimp development in aqua farms [8].

In terms of the environment, shrimp aquaculture activities must adhere to the standard operation of aquaculture standards. It ensures that production operations do not harm the environment's long-term sustainability.

3.2 Economic Analysis of Shrimp Aquaculture Business

3.3.1 Production Cost

Production costs of shrimp aquaculture are all business expenditures spent by aqua farmers in each production cycle. Production costs consist of fixed costs and variable costs. Fixed production costs are the sum of depreciation expenses for equipment. Meanwhile, variable costs are production facilities/inputs and labor costs. The following table contains information on shrimp aquaculture production costs:

Tabel 2. Average production cost of shrimp aqua farming in the study area

No	Type	Intensive Aquaculture	Semi-intensive Aquaculture	Traditional Aquaculture	Organics/ natural Aquaculture
1	Fixed Cost				
	a. Sum of Fixed Cost	**87.518.095**	**93.177.813**	**33.338.600**	**32.103.277**
	Average of Fixed Cost	**3.500.724**	**2.662.223**	**2.222.573**	**2.140.218**
2	Variable Cost				
	a. Production cost :				
	1. Shrimp fry	105.336.000	95.354.400	19.290.000	36.250.000
	2. Feed	465.869.580	468.530.834	67.078.601	0
	3. Sterilization				
	- Chlorine	2.431.250	2.876.875	0	0
	- *Samponen*	1.945.000	4.728.500	1.851.300	0
	4.Fertilizer - TSP	1.400.400	17.855.100	0	0
	5. Fermentation	2.723.000	4.629.100	0	0
	6. Probiotics	58.531.250	0	0	0
	7. Dolomite	583.500	991.950	1.683.000	0
	8. Other cost - Fuel (diese)	42.361.787	139.368.125	0	0
	9. Electricity	49.150.000	21.210.000	0	0
	10. Labor	65.835.000	59.596.500	0	0
	11. Harvest wages	0	0	4.500.000	2.250.000
	Total of variable cost	**796.166.767**	**815.141.384**	**94.402.901**	**38.500.000**
	Average of variable cost	**31.846.671**	**23.289.754**	**6.293.527**	**2.566.667**
Total Cost (TC)		883.684.862	908.319.196	127.741.501	70.603.277
Sample		25	35	15	15
Average land area (m^2)		796	1.102	3.740	31.667
Average of stocking density (Shrimp/m^2)		116	60	6	1
Total Average Cost/Cycle		**35.347.394**	**25.951.977**	**8.516.100**	**4.706.885**

The table above shows that different production expenses are required depending on the approach. Intensive systems techniques have the highest average production cost. Since the management followed the shrimp aquaculture standard, the production cost became steep. Compared to other types of aquaculture, they also utilize more advanced technology.

3.3.2 Analysis of Revenue and Income of Shrimp Aquaculture in Secanggang District

If the income earned exceeds the costs paid, the shrimp aquaculture business is profitable. In this study, the average value of total costs, revenues, and revenues is analyzed per business actor according to the size of the land area, stocking density, and management techniques. The following table contains the average value of total costs, revenues, and revenues. Details regarding the average value of total costs, revenues, and revenues can be seen in the following table.

Tabel 3. Average of Production Cost, Revenue and Income of Shrimp Aquaculture

No	Type of Shrimp Aquaculture	Production Cost/TC (Rp)	Total Revenue /TR (Rp)	Incone/(TD) (Rp)
1	Intensive	35.347.394	89.243.620	53.896.226
2	Semi-intensive	25.951.977	46.318.337	20.366.360
3	Traditional	8.516.100	14.754.667	6.238.567
4	Organics/Natural	4.706.885	9.744.000	5.037.115

The intensive type has a higher average total income than other cultivations. It is due to the high percentage of success in reducing shrimp mortality. Furthermore, it attributes to a faster acceleration of shrimp growth due to the usage of additional feed. The higher the maximum output achievement, the better the management in the firm. A study shows that the profit earned could be calculated based on the production created. The profit earned is proportional to the production yield [9].

3.3.3 Analysis of Revenue and Income of Shrimp Aquaculture in Secanggang District

The feasibility of developing shrimp aqua farming can be measured using the R/C ratio, the ratio between the total revenue and the total cost incurred by the business owner. The following table shows an analysis of the average value of the R/C ratio in shrimp aquaculture.

Tabel 1 Average cost efficiency of shrimp Aqua farming per cycle in Secanggang District

No	Aquaculture Types	Average of land area (m^2)	Production Cost/ TC (Rp)	Total Revenue/ TR (Rp)	R/C ratio (Rp)
1	Intensive	778	35.347.394	89.243.620	2,52
2	Semi-intensif	945	25.951.977	46.318.337	1,78
3	Traditional	3.740	8.516.100	14.754.667	1,73
4	Organics/Natural	31.667	4.706.885	9.744.000	2,07

Based on the R/C ratios of the four forms of shrimp aqua farming in Secanggang District, an R/C ratio of > 1 indicates that shrimp aqua farming has profited business actors.

3.3.4 Analysis of Cost and Income Difference Test on Shrimp Aquaculture in Secanggang District

The assessment of total production costs and income in four shrimp aqua farming techniques in Secanggang District determined substantial differences in production costs in the study area. Different tests were conducted using the Kruskal-Wallis test with a significance level of 5% (α = 0.05). The following table summarizes the findings of the tests performed:

Tabel 2. Kruskal-Wallis H test results

Test Statistics[a,b]		
	Income (Rupiah)	Production Cost (Rupiah)
Kruskal-Wallis H	72,228	68,643
Df	3	3
Asymp. Sig.	0,000	0,000
a. Kruskal Wallis Test		
b. Grouping Variable: Aquaculture Technique		

The table above shows that the hypothesis testing results are less than the 5% significance level, indicating that the average production costs for the four aquaculture techniques are significantly different. The results of the sig table test indicate that H0 is rejected and H1 is accepted, indicating that the production costs and income of the four shrimp aquaculture techniques in the research area are significantly different.

3.3.4 Priority Analysis of Aquaculture Technique Development With Analitic Hierarki Procees (AHP)

Analytical Hierarchical Processes (AHP) were used to prioritize the development of the shrimp aquaculture technique in Secanggang District. AHP is a decision-making technique to define a decision under hierarchical or stratified criteria conditions. The purpose of this study is to identify problems and prioritize cultivation technique development in order to accomplish goals. These criteria refer to the six pillars supporting regional development science [10].

The prioritized aquaculture technique type is determined by multiplying the supplier rankings by the weighted value obtained from the consistency ratio test multiplied by the weight of the criteria. Then, based on alternatives, obtained a priority ranking in developing shrimp aquaculture techniques. The criteria are based on a maximum score of 100 and a minimum of 0, with a classification grouping of four classes: priority class, moderate priority, less priority, and not priority[11]. The table below summarizes the results of calculations using the AHP method to determine the priority class for cultivation technique development in the research area based on the accumulated score class.

Tabel 3. Alternative priorities for the development of shrimp aquaculture techniques in Secanggang District

No	Classification	Alternative	Value	% value
1	Moderate Priority	Intensive	0,50	50,00
2	Less Priority	Semi-intensive	0,21	21,00
3	Less Priority	Traditional	0,14	14,00
4	Less Priority	Organic/natural	0,15	15,00
Total			1,000	100,00

According to the table above, the most suitable shrimp aqua farming technique has a value of 0.50 (50 percent) or a moderate priority classification. According to calculations and field observations, intensive aquaculture techniques produce more with less land. Additionally, it will eliminate the possibility of aquaculture outside the production area zone. The location criterion is the most weighted priority development of shrimp aqua farming techniques. From preparation to harvesting, good management in shrimp aqua farming refers to standard operational management in shrimp aqua farming that focuses on mitigating the worst risks associated with better management preparation.

4. Conclusion

The following conclusions are drawn from research on the development of intensive, semi-intensive, traditional, and organic aquaculture in Secanggang District, Langkat Regency, North Sumatra Province:

1. Based on the distribution analysis from the Geographic Information Technique to discover the distribution of aqua farms in Secanggang District. The total area of aqua farms in Secanggang District is ± 1,521.12 Ha. The area is distributed in the production area (±1142.96 Ha), in the converted forest area (±313.75 Ha), and the wildlife nature reserve and production forest (±24.6 Ha).

2. There are four types of Shrimp aquaculture in Secanggang District: intensive, semi- intensive, traditional, and natural/organic. There are differences in stocking density, land use (space), and shrimp aquaculture management.

3. The following data were obtained based on economic analysis: costs, income, and the efficiency of R/C ratios per cycle on four types of aquaculture. An intensive technique's average production cost is Rp. 35.347.394,- with total revenue of Rp. 89.243.620,- net income of Rp. 53.896.226,- and an R/C ratio efficiency level of 2,53. The semi-intensive technique has a production cost of Rp. 25.951.977,- total revenue of Rp. 46.381.337,- a net income of Rp. 20.336.360,- and an R/C ratio efficiency level of 1,78. The traditional technique has a production cost of Rp. 8.516.100,- with total revenue of Rp. 14.754.667,- net income of Rp. 6.238.567, and an R/C ratio of 1,73. The production cost of organic/natural technique cultivation is Rp. 4.706.885,- with total revenue of Rp. 9.744.000,- a net income of Rp. 5.037.115,- and an R/C ratio of 2.07.

4. The Analytical Hierarchy Process (AHP) method was used to develop a priority cultivation technique based on a priority analysis of shrimp aquaculture development in the Secanggang District. With a value of 0.50 (50%), shrimp cultivation using the intensive technique is the most appropriate and priority for shrimp aqua farming development in Secanggang District.

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