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Suitability Analysis of Vaname Shrimp (*Litopenaeusvannamei*) Cultivation Locations Based on the Physical and Chemical Aspects of Water in Patebon Sub-district, Kendal and Geographic Information System

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Abstract

Muflih Mulia Ramadhan, Slamet Budi Prayitno, Seto Windarto and Vivi Endar Herawati. 2021 Suitability Analysis of Vaname Shrimp (Litopenaeusvannamei) Cultivation Locations Based on the Physical and Chemical Aspects of Water in Patebon Sub-district, Kendal and Geographic Information System. Aquacultura Indonesiana, 22 (1): 10-17. *Patebon sub-district is an area that produces little Vannamei shrimp. Only about 9.3% of the pond area is used for shrimp cultivation, so it is necessary to conduct a feasibility analysis of the location to further develop Vannamei shrimp cultivation there. The purpose of this study was to analyze the feasibility of aquaculture ponds and to estimate the potential production of each sampling location based on dissolved oxygen values. The method used in this research was a case study. The sampling location was determined bya purposive sampling method.Variables used in the analysis of water quality are dissolved oxygen, salinity, brightness, depth, temperature, pH, ammonia, nitrate, and phosphate; production analysis is measured based on dissolved oxygen content. Data processing was performed using Gis 10.3 with the stages of making a basic map, spatial map based on results, scoring, overlay, and layout. The results of the site suitability analysis showed that the pond area was categorized as S1 (Very suitable) with an area of 257 Ha and S2 (suitable) with an area of 33 Ha. The estimation results of potential products based on dissolved oxygen values are1.667.790 kg.*

Keyword: GIS; Location Suitability;Clapper; Potencial poduction

Introduction

Shrimp is one type of commodity that is excellent and has an important economic value in Indonesia and even to international market. One type of shrimp that is in great demand is vaname shrimp (*L. vannamei*), that is also often referred to as pacific white shrimp. Vannamei shrimp has several advantages, which is resistant to disease fast growth, high productivity, tolerant to low temperature and salinity. (Purnamasari*et al*., 2017; Farionita*et al*., 2018).Vannamei shrimp has the potential to be developed by farmers due to its high production value that is up to 6 tonnes/ha/year (Prayitno *et al*., 2017).

Some factors influence the success of vaname shrimp cultivation, including technical, biological, social, and economic factors. One of the technical factors in Vanname shrimp cultivation is the location. Location can affect water quality, ease of access, and human resources. There are many shrimp cultivation locations in Central Java, one of the cultivation location is pond in Patebon sub-district, Kendal district. Before starting the vaname shrimp cultivation, it is necessary to know the feasibility of the location of the vaname shrimp cultivation. One of the methods that can be used in the analysis of the feasibility and suitability of the vannamei shrimp cultivation location is using remote sensing methods by Geographical Information Systems (GIS) software. Determination of cultivation locations using GIS is carried out by mapping the appropriate water quality in vannamei shrimp cultivation, such as temperature, DO, salinity, depth, ammonia (Wulandari *et al*., 2016). GIS technology can assistin determining the right location for cultivation based on measurement data for physical and chemical parameters of water (Tarigan*et al*., 2017).

This research aims to determine the feasibility of the cultivation location in terms of the quality of the pond waters in Patebon district, Kendal district, and to know the estimated production of vaname shrimp (L. vannamei) cultivation using the average dissolved oxygen availability approach. This research is supported by several studies that have been conducted in the Kendal district but have not specifically analyzed the feasibility of land for cultivation in the Patebon district, especially for Vaname shrimp cultivation. Preceding research that supports the implementation of this research includes researches conducted by Setiaji *et al*., (2018), Ristiyani (2012), Prayitno*et al*., (2017), and Haniah*et al*.,(2014).

Methodology

The instruments used in this study consisted of tools to retrieve data and tools to process data. The tools used to collect data were DO meter, refractometer, universal pH, *secchi* disk, GPS, sample bottles, boxes, and stationery. The instruments used to process the data were a laptop, ArcGIS 10.3 software, and Google Earth Pro. The materials used in this study were ammonia salicylate, ammonia cyanurate, phosphorus, nitraver, and water sample.

The research method used is a case study method. According to Ananda and Kristina (2017), a case study is a model that focuses on exploring the "bounded system" of one special case or some cases in detail by extracting data deeply. Various sources of information that are rich in context were carried out for data mining. There are several stages to conduct this research method, namely determining sampling points, collecting data, analyzing data, and determining production estimates. The location chosen was Patebon sub-district, Kendal district because there has been no similar research in the area, there are still a few cultivators who focus on Vaname shrimp cultivation, and there are many stalled fishpond areas.

Water suitability analysis was conducted by making a suitability matrix for physical and chemical parameters. The making of these criteria or suitability matrix was based on the level of influence of each parameter on the survival of the shrimp. The parameters observed were temperature, brightness, depth, salinity, pH, DO, nitrate, phosphate, and ammonia. These parameters were scored and weighted in the form of a matrix. The scoring and weighting of the suitability of the Vaname shrimp cultivation location can be seen in Table 1. After scoring and weighting, it was classified into 4 classes, namely S1 very suitable, S2 suitable, S3 not suitable, and S4 very unsuitable. The results of the Vaname shrimp cultivation location suitability scoring can be seen in Table 2.

Table 1. Suitability Scoring and Weighting ofVaname Shrimp Cultivation Location

No	Parameter	Range	Value (N)	Weight(B)	Score(NxB)	Referenve
1	DO (mg/l)	>4	4	5	20	Purnamasari*et al*. (2017)
		3,-3,9	3		15	
		2-2,9	2		10	
		1-2	1		5	
2	Termperature (^{0}C)	28-33	4	4	16	Syafaat*et al*. (2012)
		25-27	3		12	
		22-24	2		8	
		19-21	1		4	
3	Salinity (ppm)	15-25	4	3	12	Tahe*et al*. (2015)
		26-29	3		9	
		30-33	2		6	
		>34	1		3	
4	Brightness (cm)	30-40	4	3	12	Romadhona*et al*. (2016)
		25-29	3		9	
		21-24	2		6	
		<20	1		3	
5	Depth (cm)	70-120	4	3	12	Prayitno*et al*. (2017)
		60-69	3		9	
		50-59	2		6	
		40-49	1		3	
6	pH	7,5-8,5	4	4	16	Anita *et al*.(2017)
		7-7,4	3		12	
		6,5-6,9	2		8	
		6,0-6,4	1		4	
7	Phosphate (mg/l)	<0,1	4	4	16	Setyaningrum *et al*.(2014)
		0,11-0,15	3		12	
		0,16-0,20	2		8	
		>0,21	1		4	

8	Ammonia (mg/l)	<0,1 0,11-0,15 0.16-0,20 >0,21	4 3 2 1	5	20 15 10 5	Romadhona *et al*. (2016)
9	Nitrate (mg/l)	0,4-0,8 0,81-1,2 1,21-1,6 >1,61	4 3 2 1	4	16 12 8 4	Pirzan dan Utojo (2013)

Table 2. Suitability Scoring Results of Vaname Shrimp Cultivation Locations

Category	Total score	Level of Suitability	Explaination
S1	114-140	Very suitable	Verry suitable
S2	88-113	Suitable	Fulfill the minimum requirements
S3	61-87	Unsuitable	Need large inputs tofulfill minimum requirements
S4	35-60	Very unsuitable	Very hard to fulfill minimum requirements

Based on Table 1. suitability scoring and weighting of the vannamei shrimp cultivation location, the observed parameters were DO, temperature, salinity, brightness, depth, pH, phosphate, ammonia, and nitrate. Weight in that table based on how the variable take effect for life and growt of srimp, increasingly the effect it will increase as well the weight value. While in Table 2. suitability scoring results of vaname shrimp cultivation locations, scoring was divided into 4 categories, namely S1, S2, S3, and S4.

The calculation of the production analysis is carried out based on the value of dissolved oxygen content. Production analysis can be calculated based on the value of dissolved oxygen. According to Prayitno (1998), there are several stages in calculating the estimatedshrimp production based on dissolved oxygen content, namely:

1. Determine O_2 for Shrimp Production

O_2 = (DO x 75%) - 2 mg / l): 4 mg / L / kg

Information :
DO : Dissolved oxygen observed
2mg / L : minimum dissolved oxygen for live shrimp
4 mg / l : Dissolved oxygen which is recommended for shrimp cultivation

2. Determining Production Potential

Potential Production = O_2 production (kg) x Pond volume

Result

Determination of sampling points

This research was conducted in the aquaculture area in Patebon sub-district. The number of sampling station was 5 points. The sampling location was marked using GPS by Longitude and Latitude formats to obtain the coordinates of the sampling points. The area data of Vaname shrimp ponds can be seen in Table 3. The map of the sampling point can be seen in Figure 1.

Tabel 3. Description of Location Research Location Coordinates

Station	Village	Coordinate		Pond area
		Latitude	Longitude	
1	Wonosari	110,2061111	-6,87527778	1,15
2	Wonosari	110,2197222	-6,87666667	0,85
3	Kartika Jaya	110,2144444	-6,87222222	0,8
4	Kartika Jaya	110,2147222	-6,8677778	2,3
5	Kartika Jaya	110,2075	-6,86666667	14,3

The sampling location used to represent the quality of the waters in the Wonosari and Kartika Jaya villages

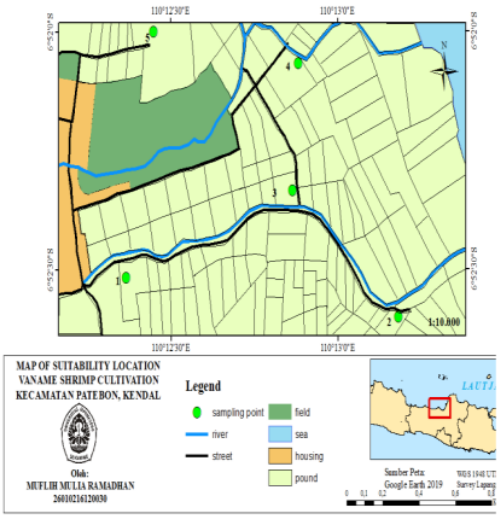

Figure 1. Map of the sampling point

Based on Figure 1.can be seen the distribution of sampling location points.

The points closest to the sea are points 2 and 5, while the farthest points are points 1. Seen in Table 3. Data on the area of Vaname shrimp. The largest area was pond 5, which is located in the village of Kartika Jaya, covering an area of 14.3 ha. The smallest pond area was pond 3, covering an area of 0.8 ha. The total area of cultivation land is 290 ha. The ratio of cultivation land at the sampling point to the whole ponds in the Patebon sub-district was 4.07%.

Water Quality

Water quality that has been measured included dissolved oxygen, temperature, pH, salinity, brightness, water depth, ammonia, nitrate, and phosphate. Water quality data can be seen in Table 4.

Tabel 4. Water Quality Data

Titik	Temperature (°C)	Salinity (ppt)	Depth (cm)	Brighness (cm)	pH	DO (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Ammonia (mg/l)
1	27,5	23	110	35	8,1	6,135	1,3	0,095	0,066
2	27,75	24	110	25	7,6	5,7	1,25	2,05	0,056
3	28	23	100	29	7,6	5,425	1,25	1,25	0,036
4	27,5	21,5	110	32,5	7,95	5,99	1,45	0,095	0,063
5	27,75	25,5	110	37,5	7,89	6,275	1,55	0,115	0,018

Based on table 4.the highest temperature value was at point 3 while the lowest points were 1 and 4. The highest salinity was point 5, while the lowest was point 4. The lowest depth was at point 3. The highest brightness was point 5, while the lowest was point 2. The highest pH point 1, while the lowest point were2 and 3. The highest DO point was 5, and the lowest point was 2. The highest nitrate point was 5, and the lowest points were 1 and 2. The highest phosphate point was 2, and the lowest nitrate point was point 1. The highest ammonia point was 1, and the lowest phosphate point was 5.

Cultivation Location Suitability Analysis

Based on the results of the research data, then it was analyzed using ArcGIS 10.3. The results of the data from the field were processed and given a score. Then the number was calculated and classified into the S1, S2, S3, or S4 categories. The suitability map of the cultivation location can be seen in Figure 2. Suitability map of cultivation location.

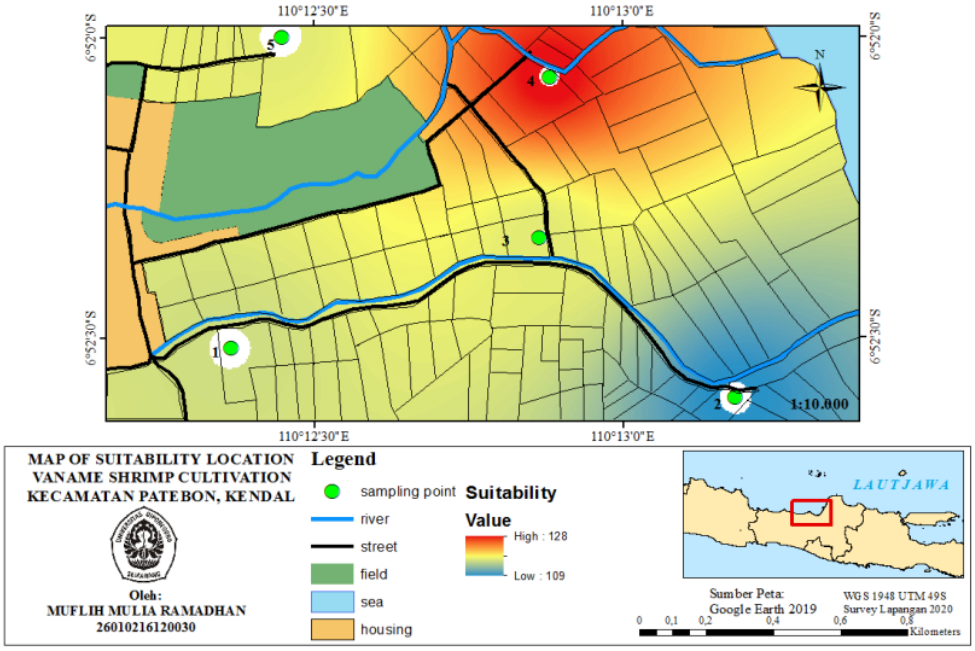

Figure 2. Suitability map of cultivation location

Based on the map of the location at sampling point 2, the scoring values obtained ranged from 88-113, which indicates that these points are in the S2 category that is suitable. While sampling points 1, 3, 4, and 5, the scoring values obtained ranged from 114-140. It means that the sampling point was classified as the S1 category, which is very suitable.

Analysis of Production Estimation

Based on the results of the oxygen demand of vaname shrimp, an estimated analysis of vaname shrimp production could be conducted. The analysis was conducted by calculating oxygen production, oxygen demand, number of living shrimp, seed requirements, and stocking density. Production estimation analysis can be seen in table 5.

Tabel 5. Analysis of Production Estimation

Whole production estimation (kg)	Actual production result (kg)	Presentase estimation and production result (%)
1.667.790	93.500	5,6

Seen from Table 6. Estimated production based on dissolved oxygen and the entire area in Wonosari and Kartika Jaya villages is 290 ha. It is found that the estimated production that can be produced is 1,667,790 kg. The current production results are 93,500 kg. The percentage between estimation and production result is 5.6%.

Discussion

Analysis of Cultivation Location Suitability

The sampling points were distributed in Patebon sub-district, Kendal district, Central Java. The sampling points were selected by purposive sampling method. It was intended that the selected point was considered to be able to describe the condition of the water around the sampling point area. The location is selected based on distance from the sea and the river. This is suitable as the statement of Kusumawardani (2013) that purposive sampling is a sample taken by certain criteria to obtain the desired objectives. The location was chosen based on several aspects, namely the distance from the water source, the productive ponds, the ease of reaching the area, and the existing access to the area.

The result obtained from the measurement of water quality was dissolved

oxygen, which was 5,425–6,275 mg/l. The lowest dissolved oxygen value was pond 3, which was 5.425 mg/l, and the highest was in pond 5, which was 6.275 mg / l. All points are suitable for Vaname shrimp cultivation that is more than 4 mg/l (Suwoyo *et al*., 2013 and Susilowati*et al*., 2017). The salinity obtained in the study ranged from 21 to 25.5 ppt. The highest salinity value was at point 5, while the lowest was at point 4. The results of the salinity value at points 1, 2, 3, and 4 meet the good standards for shrimp growth, while point 5 does not meet the standards for shrimp growth, but it still could be tolerated by shrimps. According to Syukri (2016), Dahlan*et al*., 2017 and Widiyanti (2017), shrimps are euryhaline that can survive in the salinity ranged from 5 to 50 ppt. The temperature obtained from the research results ranged from 27.5 to 28°C. The temperature obtained has met the standards for shrimp cultivation, which is 22-31 ^{o}C (Syafaat *et al*., 2012). A temperature that is too high or too low can cause stress on shrimp (Zufadhillah*et al*., 2018). The brightness obtained from the study was 25-37.5 cm. The lowest brightness value was at point 2, which was 25 cm, and the highest brightness was at point 5, which was 37.5 cm. The brightness values obtained were in very suitable to the very unsuitable category. Points 1, 4, and 5 were classified as very suitable categories, while points 2 and 3 were classified as suitable categories. According to Romadhona*et al*. (2016), good brightness for Vaname shrimp fishponds is between 30-40 cm. Brightness can be affected by light intensity, and suspended solids included feces, food residue, and plankton (Raunsay *et al*., 2016; Anas*et al*., 2015; Umammi*et al*., 2018 and Kusuma*et al*., 2017). The obtained depth of the vaname shrimp pond water was 100-110 cm. The lowest water depth value was at point 3, which was 100 cm, while points 1, 2, 4, and 5 have the same water depth, which was 110 cm. The results obtained are suitable for Vaname shrimp cultivation. According to Prayitno*et al*., (2017) and Susanto*et al*., (1998), the ideal water depth for shrimp cultivation is 70-120 cm. The depth difference is influenced by the construction of the pond (Haryono *et al*., 2014). The pH value obtained from the study ranged from 7.6-8.1. The lowest pH value was obtained at points 2 and 3, which was 7.6. The point that has the highest pH value was point 1, which was 8.1. The pH value obtained was still classified as optimal. Anita*et al*. (2017) stated that the suitable pH for vaname shrimp cultivation is between 7.5-8.8. pH can be influenced by carbonate levelslevels in the waters (Sukimin*et al*., 2016). Ammonia obtained from research that has been carried out was 0.0184-0.06625. The highest ammonia value was at point 1, while the lowest was at point 5. The range of ammonia obtained was excellent for vaname shrimp cultivation. This is per the conditions of SNI 8037.1 (2014) that the good ammonia value for the growth of Vaname shrimp is less than 0.1 mg/l. The results of nitrate measurements that have been carried out were 1.3–1.55 mg / l. The highest nitrate value was found at point 5, which was 1.55 mg/l, while the lowest at points 2 and 3, which was 1.25 mg/l. The nitrate content obtained was in the high category. The nitrate level in good water is 0.4-0.8 mg/l. This is similar to Pirzan and Utojo (2013), in that the optimal nitrate concentration for vannamei shrimp cultivation is 0.4-0.8 mg/l. A high level of nitrate is influenced by relatively low oxygen, so the denitrification process is inhibited, and then the nitrate and nitrite ions will be hard to convert into nitrogen molecules (N_2).

As a result, the nitrate content in the water will increase (Rukminasari*et al*., 2014; Rudiyanti*et al*., 2014 and Tungka*et al*., 2016). Phosphate levels resulting from water measurements at the sample point ranged from 0.095-2.05 mg/l. According to the statement of Haniah*et al*. (2014) and Ikbal*et al*., (2019), a good phosphate concentration for intensive shrimp cultivation is not more than 0.2 ppm. It indicates that points 1, 4, and 5 are suitable for intensive shrimp cultivation because their phosphate concentration was less than 0.2 ppm. According to Hartoko*et al*. (2016) and Patty (2015), phosphate concentration in water can be influenced by water depth, water sources, and pond location.

Based on the results of the water quality, it showed that stations 1, 3, 4, and 5 were included in the S1 category, which was very suitable. Sampling point 2 was classified as S2 category which was appropriate. The scores obtained from points 1, 3, 4, and 5, which were 116, 117, 128, and 117 were included in the S1 category. While point 2, namely 113, was included in the S2 category. There are several assessments that are below the average, namely the value of nitrate, phosphate, brightness, and salinity so that point 2 was included in the S2 category, which was appropriate. According to Rohman*et al*. (2018), the land that will be used for aquaculture ponds must meet physical, chemical, and biological requirements. These aspects become a supporting element in the

development of a coastal pond fishery business so that it can be used as a basis for assessment in designing land suitability models. So, the value of each aspect can determine the appropriateness of water.

Production Estimates

Production estimates are calculated using the dissolved oxygen content available in each test pond. Dissolved oxygen is calculated based on the shrimp's need for oxygen. Then proceed to calculate the estimated productionThe estimated production based on Disolved oxygen is 1,667,790 kg / 290 ha, so if calculate the unit of ha, it is 5,751 kg / ha. This numbers is considered good because it is almost close to 6,000 kg / ha. According to Prayitno*et al*., 201 8 that good shrimp productivity reaches 6 tonnes / ha / cycle. Not only dissolved oxygen, production estimates are strongly influenced by several things, such as density, oxygen, genetics, the ability to utilize feed. This is similar to Susilowati*et al*. (2017) stated that shrimp production is influenced by the availability of oxygen, heredity, sex, age, density, parasites and disease and the ability to use feed.

Conclusions

The sampling points that have been studied show that the sample location area of 257 ha is in the S1 category which is very suitable and 33 ha is in the S2 category which is suitable.The production potential obtained is 1,667,790 kg with an area of 290 ha or 5,751 kg / ha.

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