International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com || Volume 11 - Issue 08 || August 2025 || PP. 15-26

A Cluster Analysis of the Carrying Capacity and Land Suitability for Shrimp Farming in the Coastal Pond Area of Banten Bay Indonesia

Mochammad Farkan[1], Afandi Saputra[1], Mugi Mulyono[1],
Aditya Brahmantyo[1], Margono[1], Lakonardi Nurraditya[1], Suharjo[2],
Rochyan Aglan[2], Uus Bustomi[2]
[1]*Jakarta Technical University of Fisheries, Jn. Raya AUP No.1, Pasar mInggu, Jakarta Selatan, DKI Jakarta12520*
[2]*Serang Regency Fisheries Service, Jl. Brigjen KH Samun No.7, Kotabaru, Kec. Serang, Serang City, Banten 42112*

Abstract: Production of shrimp farming in ponds within an area fluctuates greatly, with some farmers even closing their businesses due to failure. The sustainability of shrimp farming is influenced by the suitability of the land and its carrying capacity. This study aimed to evaluate a cluster model based on environmental carrying capacity and land suitability, despite limited water supply, in the coastal aquaculture area of Banten Bay. The research was conducted from November 2024 to January 2025. The research method involved observing and measuring the water, soil and biogeophysical parameters of the area. Measurements were carried out in the field and in the laboratory at the Polytechnic of the Fisheries Business Expert. Tidal parameters play an important role in providing water for shrimp farming. Perspective random sampling was conducted at nine points, covering a pond area of 5,028.3 hectares.Data analysis using formulas, tabulations and GPS devices. Processing data using Excel and SPSS. The results showed that nine locations were suitable for farming vaname shrimp, with Wanayasa achieving the highest score and Sawah Luhur the lowest. Carrying capacity is measured by the availability of water to receive and process waste from shrimp farming. The volume of water in each cluster is between 17,500 and 35,000 m^3, which can support 228.2 ha of sustainable, intensive shrimp farming, accounting for 0.0453% of the total pond area, with the capacity to produce 3,002.8 tonnes per cycle. If managed using semi-intensive technology, the land area would be 428.97 ha, whereas using traditional technology it would be 5,004.66 ha. Mangroves play an important role in reducing waste, but currently there are only 38.97 hectares. Therefore, it is necessary to plant more mangroves to reach a total of 93.39 hectares.
Keywords: water quality, area, sustainability, waste, production

I. Introduction

Continuous shrimp farming in ponds can lead to environmental degradation, marked decreases in water quality and environmental carrying capacity, and reduced land suitability. Shrimp farming operations that do not consider land potential, suitability and carrying capacity can cause long-term environmental problems and complications. This indicates a problem in the environmental dimension of the sustainable development of coastal cities, requiring serious intervention to improve environmental quality (Krisnanta et al., 2024). The productivity of shrimp farming in coastal ponds in Banten Bay is 510 kg–11 tonnes/ha/cycle. While pond production was quite high in 1985, it began to decline in 2001. Land carrying capacity and suitability change dynamically in a given year with respect to development in coastal and upstream areas, which result in waste being brought into the sea of Banten Bay, thereby decreasing productivity. It is therefore necessary to analyse the carrying capacity of natural resources and environmental management, evaluating sustainability and productivity. A land suitability evaluation predicts how well the land will perform in terms of the benefits and constraints of productive land use, as well as the expected environmental degradation due to land use. Land suitability is a key factor influencing the success and sustainability of aquaculture activities (Filgueira et al., 2015). In order to be sustainable, suitable land must also have production capacity, as measured by carrying capacity.

Carrying capacity (CC) is defined as an ecosystem's ability to support a certain population size with sufficient food, habitat, space and other necessities. (Zulfikar, 2023). Another definition of CC is the maximum population density that can be maintained by biota in relation to its environment, providing for its needs with respect to food, habitat and water, and taking into account production and ecological scenarios (Islam et al., 2024). In contrast, ecological carrying capacity (ECC) is a concept that considers production capacity, interactions between species and the environment, and environmental capacity (Cooper, 2007; Ross et al., 2013).According to Weitzman and Filgueira (2020), CC aquaculture is divided into three categories. (2020), CC aquaculture can be divided into three categories: 1) Physical carrying capacity: the total area available for aquaculture. Production carrying capacity is the stocking density that yields the most production and is also referred to as production capacity. Ecological carrying capacity is the amount of aquaculture production that can be supported without causing ecological decline in terms of species, populations or communities (Filgueira et al., 2015).In the aquaculture industry, social carrying capacity is defined as the level of fisheries that can be supported by the community (Long, 2022). The CC scale can be interpreted in terms of CC population (individual species), CC community (several interacting species), CC ecosystem (community interaction) and CC biosphere (ecosystem interaction) (Rifalda et al., 2023). CC is used as a reference in the management of commercial fisheries, forestry and agricultural resources (Hilborn et al., 1995) and has been employed to evaluate the success of ecosystem-based sustainable aquaculture (Cooper, 2020; Link & Marshak, 2022).

Exceeding the carrying capacity of the pond environment will result in a decrease in its ability to support shrimp life due to changes in environmental quality. For this reason, pond capacity analysis, also known as environmental carrying capacity analysis, is important and must be considered. The carrying capacity of a pond farming area is a quantitative measure of its production potential based on the area of water available. The results of the calculation can be used to determine technology, stocking density and other resources without causing environmental degradation. Carrying capacity analysis of the aquatic environment can be used to determine the land's potential and suitability for achieving production targets. The relationship between carrying capacity and land suitability is closely linked to sustainable shrimp farming. Therefore, this study analyses the integration of CC and land suitability in sustainable shrimp farming.

II. Materials and Methods

1. Study area and time

The research was conducted from November 2024 to January 2025 in the coastal area of Banten Bay, on the border between the villages of Banten and Tengkurak, at the coordinates 05°57'13" LS 106°06'06" East (Fig. 1).

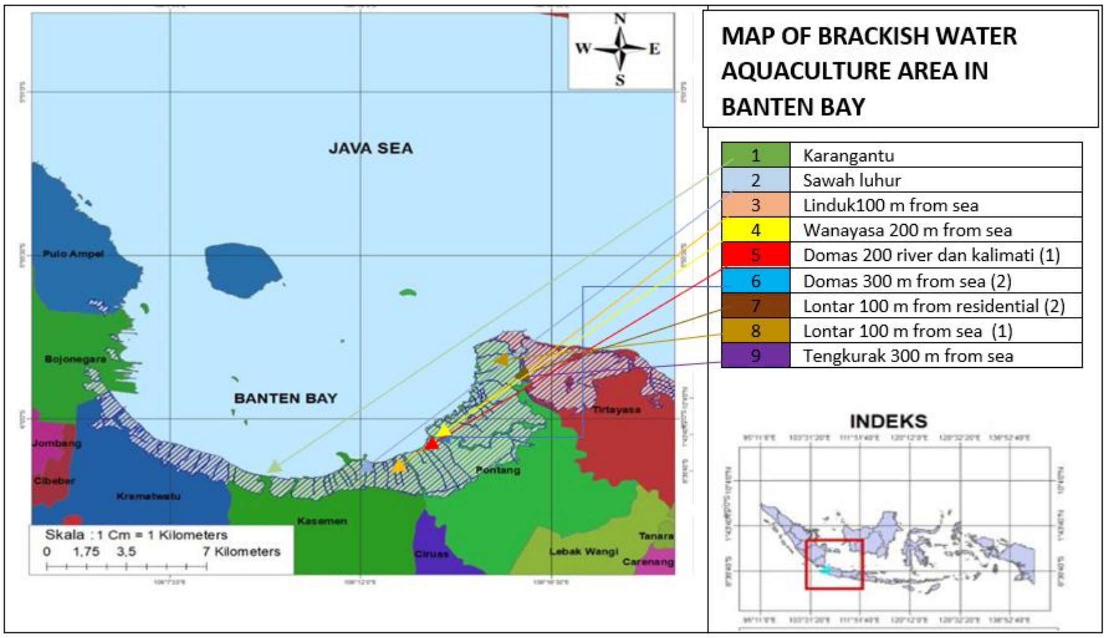

Figure 1: Map of the research location

This research uses the methods of observing and measuring water quality, soil and biogeophysical parameters in the field and in the laboratory of the Polytechnic of Fisheries Business Experts.

2. Existing conditions

The total area of ponds on the coast of Banten Bay is 5,028.3 hectares, most of which are traditional ponds. The main commodities raised in these ponds are shrimp, milkfish and other types of fish.

3. Measurement of water quality parameters

The water quality parameters measured and analysed in this study are dissolved oxygen (DO), water pH, salinity, BOD5, NH_4 and temperature (Leidona et al., 2024). Soil parameters include texture, redox potential, soil pH and biogeophysics, consisting of distance from the sea, distance from the river, and mangrove forest area. Water sampling was conducted using a random sampling method at nine observation points: Karangantu, Sawah Luhur, Linduk, Domas 1, Domas 2, Wanayasa, Lontar 1, Lontar 2 and Tengkurak. Each observation point was sampled three times over three months. Salinity was measured using an Atago refractometer; temperature, using an alcohol thermometer with a scale of 0–100 °C; pH, using a pH meter; and DO, using a DO meter. Ammonia was measured using a Merck test kit. Water quality measurements were carried out in the field and laboratory using tools such as test kits, refractometers and hydrogen potential meters. Tidal measurements were taken at the beach and aquaculture channel of each observation location. Tidal measurements were carried out over 30 days at 30-minute intervals. This is based on tidal phenomena in the area. The results of the tidal measurements were corrected using data from the nearest stations: Karangantu and Domas.

4. Measurement of carrying capacity

The method of measuring environmental carrying capacity is based on the availability of water to accommodate aquaculture waste, and has been employed by several researchers (Widigdo & Pariwono, 2003; Prianto et al., 2006; Roque d'Orbcastel et al., 2008; Prasita, 2007; Jung et al., 2024; Zhao et al., 2025). This method of environmental carrying capacity analysis refers to the relationship between the quantity of water used for pond inputs and the resulting organic waste load. The calculation of the volume of water used for aquaculture is as follows (Widigdo & Pariwono, 2003):

$V\ waters = 0.5hy\left\{2\ x\frac{h}{\tan\theta}\right\}$……………………………………………………………………………………1

Y is the length of the area's coastline, h is the tidal range, x is the distance from the shoreline at high tide towards the sea until the water depth at low tide reaches one metre and is no longer affected by turbulent bottom currents, and θ is the angle of the beach slope. The formula for calculating the area suitable for shrimp farming is as follows:

Intensive pond area: Volume of water supply / 100 x 10 x existing production per Ha …………………………..2
Semi-intensive pond area:
Semi-intensive pond area: Intensive pond production per ha/existing semi-intensive production. ………………3
Extensive farm size: Intensive pond production per ha/existing extensive production: …………………………..4

The value assigned to each of these parameters is determined using weighting. The weighting of each parameter is determined based on its dominant influence on the feasibility of shrimp farming in the pond. The weight and score of each parameter are adjusted according to the magnitude of its influence on the value of suitability, using the following formula:

$Nij = \sum Bini{=}1\ xSij$ 5

Where: Nij = Total suitability score at farm-j
Bi = Weight on each parameter-i
Sij = Score on each parameter-i of class-j

Scoring is done to assess the limiting factors on each parameter. The research process can be described in the scheme in Fig. 2 below.

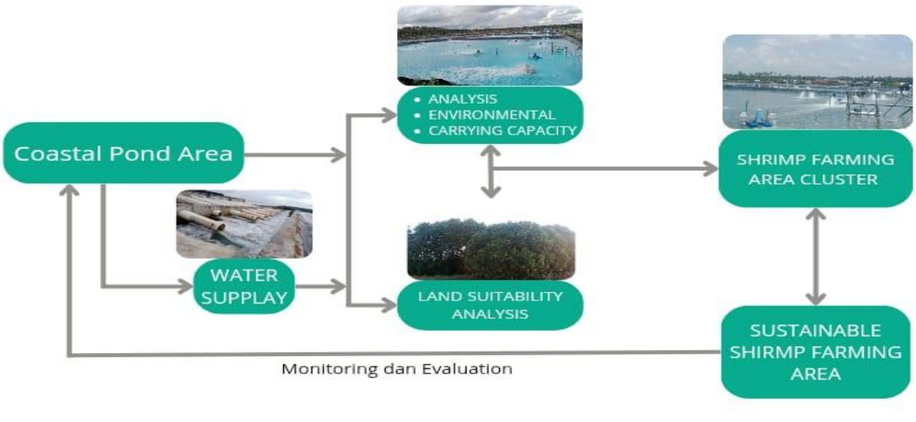

Figure 2: Schematic of the research process

III. Results and Discussion

The first stage of the land suitability analysis involves compiling the scores and weights for the suitability of the Vaname shrimp farming areas. The results are shown in Table 1.

Table 1: Score and weight index of vaname shrimp farming area suitability

No	Parameter	Measurement Result	Weight	Value
A	Water Parameter			55
1	Temperature (^{o}C)	28 -30	4	6
		26-28; 31-32	3	
		23-26; 33-34	2	
		<23 ; <35	1	
2	DO (mg L^{-1})	6-7	4	10
		5-6; 7-8	3	
		3-4	2	
		<2	1	
3	pH	7-8,5	4	4
		6-7 ; 8,5 – 9	3	
		4 -5	2	
		<4	1	
4	Salinity (g L^{-1})	15-25	4	8
		10-15 ; 26 - 30	3	
		5-10 ; 31-36	2	
		<5 ; < 36	1	
5	Amoniak (mg L^{-1})	< 0,01	4	7
		0,01 – 0,03	3	
		0,04-0,5	2	
		>0,6	1	
6	Tides (m)	2-3	4	20
		1,5-2	3	
		0,7-1,5	2	
		<0,7; < 3	1	
B	Soil Parameter			25
1	Redox Potencial (mV)	Positif	4	5
		0 – (-100)	3	
		-100 – (-150)	2	
		>-150	1	
2	Textur	Sandy clay Clay	4	10
		Clay dusty	3	
		Sandy	2	
			1	
3	pH	6-7	4	5
		5-6	3	
		4-5	2	
		<4	1	
4	KTK (me/100gr)	>30	4	5
		20-30	3	
		11-20	2	
		<10	1	
C	Biogeofisik			20
1	Distance from the sea (m)	<500	4	5
		500 – 1000	3	
		1000 – 2000	2	
		>2000	1	
2	Distance from river (m)	<500	4	5
		500 – 1000	3	
		1000 – 2000	2	
		>2000	1	

3	Length of mangoree line from low tide (m)	>400	4	10
		100 – 400	3	
		10- 100	2	
		<10	1	

Description:
Value 1: N = Not suitable; Value 2: S3 = Moderately suitable; Value 3: S2 = Suitable; Value 4: S1 = Very suitable.
The results of the water quality measurements are tabulated in Table 2 below.

Table 2: Recapitulation of pond water quality measurement results

No	Location	Temperatur °C	Water pH	Salinity (ppt)	DO (mg/l)	Amonia (mg/l)	Tides(m)
1.	Karangantu	28±2	6,7	15±7	3.3	< 0,5	0,75
2.	Sawahluhur	28±2	6.7	20±12	3,5	<0,5	0,11
3.	Linduk100m from sea	29±2	7	25±9	3,2	0.3	0,11
4.	Wanayasa200m from sea	29±2	7	27±5	3	0.1	0,11
5.	Domas200river dankalimati (1)	28±3	7	29±6	3	0	0,85
6.	Domas300mfrom sea (2)	28±2	7,5	27±9	3,4	0	0,11
7.	Lontar 100 m dari residential (2)	29±3	7	28±7	3,5	0	0,90
8.	Lontar 100 m from sea (1)	29±3	7,5	27±10	3,1	0	0,11
9.	Tengkurak 300 m from sea	29±3	7	22± 8	4	70,07	69

The results of the conversion using these indices and standards, which will be employed to determine the level of land suitability, are presented in Table 3 below.

Table 3: Measurement results of water quality and quantity at each location

Location	Temperature (°C)			DO (mg L^{-1})			Amoniak (mg L^{-1})			Tides (m)			Total			Total
	Value	Weight	Sub Total	Value	Weight	Sub Total	Value	Weight	Sub Total	Value	Weight	Sub Total	Value	Weight	Sub Total	
Karangantu	4	6	24	2	10	20	2	8	16	2	7	14	2	20	40	114
Sawahluhur	4	6	242	2	10	20	2	8	16	2	7	14	1	20	20	312
Lnduk	4	6	4	2	10	20	3	8	24	3	7	21	2	20	40	109
Domas 1	3	6	18	2	10	20	3	8	24	3	7	21	2	20	40	123
Domas 2	4	6	24	2	10	20	3	8	24	3	7	21	2	20	40	129
Wanayasa	4	6	242	2	10	20	2	8	16	2	7	21	2	20	40	339
Lontar 1	3	6	18	2	10	20	2	8	16	3	7	21	2	20	40	115
Lontar 2	3	6	18	2	10	20	3	8	16	3	7	21	2	20	40	115
Tengkurak	3	6	18	2	10	20	2	8	16	3	7	21	2	20	40	115

Score = Value x weight in the index table

The results of the water temperature measurements were between 26.5 and 30.2 °C, which indicates that the pond is in optimal conditions. According to Anjaini (2024), the ideal temperature for shrimp is between 25 and 30 °C. The results of the water pH measurement were between 6.9 and 8.5. Araujo et al. (2024) state that a pH level of 7-8.5 is ideal for the life and growth of fish or shrimp. The degree of acidity (pH) is a chemical property of water that affects the growth and development of shrimp. The salinity value obtained was 10-35 ‰, spread across several measurement points. Good salinity for fish and shrimp farming activities is 10-25 ‰

(Ariadi et al., 2021; Yunarty, 2022). The dissolved oxygen content at the observation site ranges from 3.40 to 5.92 mgL^{-1}. Boyd et al. (1995) state that the ideal dissolved oxygen content is 4–8 mg/L. Based on the measurements obtained, the ammonia value ranges from 0 to 0.683 mgL^{-1}. The lowest ammonia value was found at the Lontar 2 and Tengkurak locations, at the end of the river near the Pontang headland, with a value of 0.683 mgL^{-1}.

Tides in aquaculture areas play a very important role in supplying water to shrimp farms as needed. Sufficient seawater facilitates aquaculture water management, including initial stocking, water replacement, reduction of organic waste and maintenance preparation, consisting of drying, construction, processing and improving water and soil quality. Good tides for shrimp farming are 2–3 m (Farkan et al., 2017). The brightness of shrimp ponds is also affected by the water supply: Mustafa et al. (2008) stated that the brightness of the waters is higher during high tides because the influence of the brighter sea is more significant at this time.

The 29 km-long coastline has muddy beaches composed of sedimentary or alluvial soils. The flat, undulating terrain has an elevation of 0–1%. The height of the tide from the zero datum is between 90 and 110 cm. In August, the tide is so low that it drains most of the ponds that rely on it. The large rivers are the Cengkok, Cibanten, Wadas, Ciujung and Pamong. The results of the soil quality measurements are shown in Table 5 below.

Tabel 5: Results of soil quality measurements in coastal Banten Bay

No	Village name	pH H_2O	Soil Textur Sand	Dust	Clay	Classification of soil textures	redox(mV)	KTK	Elevation of pond platform (m)
1	Karangantu	6,4	12	49	39	Dusty clay loam	175	23,61	1,1
2	Sawahluhur near the sea	7,0	14	46	40	Clay	185	28,23	1,1
3	Linduk 100 darilaut	6,1	26	22	52	Clay	213	28,04	1,0
4	wanayasa 200 mfrom sea	7,8	53	19	28	Sandy clay loam	169	17,80	1,1
5	Domas 200 sungai dan kalimati (1)	7,1	10	30	60	Clay	184	29,85	0,8
6	Domas300m From sea (2)	7,3	26	40	34	Silty clay	157	23,02	0,9
7	Lontar100m from the Settlement (1)	7,8	27	57	16	Loam	185	7,49	0,7
8	lontar100m darilaut (2)	7,8	34	47	19	Clay	143	9,98	0,9
9	Tengkurak 300mfro, sea	8,2	33	30	37	Silty clay	127	21,71	0,7

Based on the results of the field measurements, the following data were obtained:- pH (H_2O; KCl): the pH range of H_2O is 5.5–8.2, while the pH range of KCl is 4.8–7.6. The higher pH value of H_2O indicates that the soil is new and has potential for agricultural and aquaculture development. There is a significant positive correlation between the difference in pH and pH_o (i.e. pH minus soil pH and soil cation exchange capacity; the higher the cation exchange capacity, the greater the difference in pH). The table below outlines the pond soil requirements for maintaining vaname shrimp (Litopenaeus vannamei) in ponds using intensive technology (SNI 01-7246-2006). Table 4.17 describes the soil quality parameters for shrimp farming in ponds.

Soils with a high cation exchange capacity (CEC) are better able to trap and provide nutrients than soils with a low CEC. The higher the organic matter content of a soil, the higher its CEC (Supriatna et al., 2020). CEC is a chemical property closely related to soil fertility. Soils with a high CEC can trap and provide nutrients more effectively than soils with a low CEC. Soils with high CEC that are dominated by basic cations (Ca, Mg, K and Na) can increase soil fertility, whereas those dominated by acidic cations (Al and H) can reduce it

(Hardjowigeno and Widiatmaka, 2007). (Hardjowigeno & Widiatmaka, 2007). Soil CEC can be qualitatively determined by its texture. Soils with a high sand content have a lower CEC than soils with a high clay or dust content. The CEC of low-CEC soils can be increased by adding organic materials such as compost or manure.

Adding crushed zeolite rock can also significantly increase soil cation exchange capacity (CEC) (Novizan, 2005). Cations are positively charged ions, such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, NH_4^{+}, H^{+} and Al^{3+}. In soil, these cations are either dissolved in groundwater or absorbed by soil colloids. The number of cations (in milliequivalents) that can be absorbed by the soil per unit weight (usually 100 g) is called the cation exchange capacity (CEC). In most soils, cation exchange capacity changes as the soil pH changes. At low pH, only the permanent charge of clay and some of the organic colloidal charge hold ions that can be replaced through cation exchange, resulting in a relatively low CEC (Harjowigeno, 2002). One way to increase soil pH is liming. While liming can increase the CEC, this increase is only temporary as, over time, the cations are absorbed by plants or washed away, causing the CEC to decrease again (Hardjowigeno and Widiatmaka, 2007).

The soil texture in the coastal area of Banten Bay consists of dusty clay, clay, sandy clay loam and clayey loam. Sand and silty sand soils are not ideal for ponds as they are highly porous and nutrient-poor (Mustafa et al., 2008). Sandy clay, clay loam and clay soils are ideal for pond construction (Schmittou, 2004). Sandy loam is the best soil texture for making embankments, and loam facilitates chemical and physical interaction with the outside environment (Treece et al., 1999). Soils with high clay and silt content are good, and the more fertile the soil, the more klekap grows. Silty loam soils are very good for klekap growth, while loam and silt soils are still good. Sand and silty sand soils are not suitable for ponds as they are highly porous and lack nutrients (Mintardjo, 1984). Clay soil is ideal for building ponds (Ting et al., 2015). The ideal soil texture for shrimp farming is sandy clay or clay loam because it is compact and strong and can withstand water without breaking (Ting et al., 2015). (Arsad et al., 2017). Increasing the sand content by 21.08% or the clay content by 30.0% can increase vaname shrimp production (Mustafa, 2019). The ideal texture is clay (60–70%) and sand (30–40%) (SNI 01-7246-2006). The results of the conversion to standards and land suitability are shown in Table 6 below.

Table 6:These are the results of converting values to the standard and index of soil parameter suitability at each location.

Location	Redox potential (mV)			Textur			pH			KTK (me/100gr)			Total
	Value	Weight	Total	Value	Weight	Total	Value	Bobot	Total	Value	Weight	Total	
Karangantu	1	5	5	3	10	30	4	5	20	3	5	15	70
Sawah luhur	1	5	5	2	10	20	4	5	20	3	5	15	60
LInduk	1	5	5	2	10	20	3	5	15	3	5	15	55
Domas 1	1	5	5	3	10	30	4	5	20	3	5	15	70
Domas 2	1	5	5	2	10	20	4	5	20	3	5	15	60
Wanayasa	1	5	5	3	10	30	4	5	20	4	5	20	75
Lontar 1	1	5	5	3	10	30	4	5	20	1	5	5	60
Lontar 2	2	5	10	2	10	20	4	5	20	1	5	5	55
Tengkurak	2	5	10	3	10	30	4	5	20	3	5	15	75
Jumlah													

core = Value x weight

While the results of biogeophysical measurements are shown in table 7 below.

Table 7: Recapitulation of the results of biogeophysical measurements taken during shrimp farming in ponds.

No	Location	Mangrove (m)	Distance from river (m)	Distance from the coast (m)
1	Karangantu	10-300	100	600
2	Sawahluhur Near sea	10-200	800	400

3	Linduk 100 From sea	20-200	900	900
4	wanayasa 200 mdarilaut	10-200	70	150
5	Domas 200 m from river kalimati (1)	20-300	600	1500
6	Domas300m darilaut (2)	10-300	50	100
7	Lontar100m from settlement (1)	2-200	100	250
8	lontar100m from sea (2)	2-200	50	100
9	Tengkurak 300mfrom sea	10-300	50	100

The table 8 below shows the conversion results with biogeophysical standards.

Table 8:Results of biogeophysical measurements at each location

Location	Distance from the sea			Distance from the river			mangrove			Total
	Value	Weight	Total	Value	Weight	Total	Value	Bobot	Total	
Karangantu	4	5	20	4	5	20	3	10	30	70
Sawah luhur	3	5	15	3	5	15	3	10	30	60
LInduk	3	5	15	3	5	15	3	10	30	60
Domas 1	4	5	20	3	5	15	3	10	30	65
Domas 2	3	5	15	4	5	20	3	10	30	65
Wanayasa	4	5	20	4	5	20	3	10	30	70
Lontar 1	4	5	20	4	5	20	3	10	30	70
Lontar 2	3	5	15	4	5	20	3	10	30	65
Tengkurak	4	5	20	4	5	20	3	10	30	70

The conversion results are summarised to determine the level of land suitability.

Table 9: Recapitulation of the index and standard conversion

No	Location	Water quality	Soil quality	Biogeofisik	Total	Conclusion
1.	Karangantu	126	70	70	266	Suitable
2.	Sawah luhur	106	60	60	226	Suitable
3.	LInduk	121	55	60	236	Suitable
4.	Domas 1	135	70	65	270	Suitable
5.	Domas 2	145	60	65	270	Suitable
6.	Wanayasa	133	75	70	278	Suitable
7.	Lontar 1	127	60	70	257	Suitable
8.	Lontar 2	131	55	65	251	Suitable
9.	Tengkurak	127	75	70	272	Suitable

All the points fall into the correct category, with Wanayas having the highest value and the Sublime Rice Fields having the lowest.

1. Analysis of carrying capacity

Table 10:Measurement results for the quantity of seawater used in shrimp farming.

No.	Location	Water Volume (m3)
1.	Karangantu	27000
2.	Sawah luhur	14000
3.	Linduk	25800
4.	Domas 1	20400

5.	Domas 2	17500
6.	Wanayasa	35000
7.	Lontar 1	27000
8.	Lontar 2	30000
9.	Tengkurak	31500

These data show the carrying capacity and technology used in an area, as shown in Table 11 below.

Table 11: Shrimp farming area

Location	Intensive Area (Ha)	Production (Ha).ton	Intensive (ton)	Semi intensive (Ha)	Extensive
Karangantu	27	13	351	50.14	585
Sawah luhur	14	10	140	20	233.33
Linduk	25.8	14	361.2	51.6	602
Domas 1	20.4	14	285.6	40.8	476
Domas 2	17.5	13	227.5	32.5	379.16
Wanayasa	35	14	490	70	816.66
Lontar 1	27	14	378	54	630
Lontar 2	30	12	360	51.42	600
Tengkurak	31.5	13	409.5	58.5	682.5
Total	228.2		3002.8	428.97	5004.66

Estimating the land's carrying capacity using a physical approach is closely related to the area of suitable land (classes S1 and S2) and the design model for developing shrimp farms. Widigdo and Pariwono (2003) stated that, to prevent pollution, the volume of seawater receiving waste must be at least 100 times greater than the volume of waste discharged. Based on this statement, the maximum quantity of waste that can be disposed of is 27,000/100 = 270 m³. If 10% of the pond water is discharged daily for intensive cultivation, the maximum quantity of pond water is 2,700 m³. Therefore, the maximum quantity of pond water is 10% of the quantity of seawater entering coastal waters every day. The available water quantity of 27,000 m³/day can accommodate, dilute and assimilate all incoming waste without causing harmful effects. Waste entering coastal and marine waters interacts with seawater, producing typical waste behaviour involving evaporation, dissolution and dispersion (Ismail, 2022). Seawater dynamics can also cause waste to move from its place of origin to other places, resulting in subsequent changes in waste concentration, intensity, and the magnitude of its environmental impact at certain times and locations.

If the maximum quantity of water in the pond is 2,700 m³, it can be predicted that the sustainable pond area around Karangantu is 270 ha if managed intensively (at a water level of 1 m). If the maximum productivity of intensive ponds is 12 tonnes/ha/season (Farkan et al., 2025), then the maximum production of the ponds around Karangantu is 378 tonnes/cycle. If semi-intensive technology is applied with a maximum productivity of 7 tonnes/ha/season, the sustainable pond area around Karangantu would be 54 hectares. If traditional technology is used, with a maximum productivity of 0.6 tonnes per hectare per cycle (Farkan, 2017), the sustainable pond area or carrying capacity of pond land in the Balusu district is 630 hectares. However, the carrying capacity of an environment can vary across different species and change over time as a result of various factors, including food availability, water resources, environmental conditions, and living space (Newell, 2007).

The receiving water body must collect aquaculture effluent so that the waste degradation process can be guaranteed and pollution at sea can be avoided. A buffer zone needs to be provided within the aquaculture area. This buffer area should be land bordering the sea or river that is not used for aquaculture, but rather for growing native mangrove vegetation. Mangroves naturally protect against storms and strong winds, and they serve as nurseries and feeding grounds for various economically important species, such as shrimp, crabs, fish, and oysters. These buffers also trap sediment, protect water quality, retain toxic materials and slow the flow of surface water. According to Article 27 of Presidential Decree No. 32 of 1990 concerning Protected Area Management, this area must be provided as a green belt with a minimum width of 130 times the average difference in metres between the highest and lowest annual tides, measured from the lowest tide line. When managing coastal and marine resources, it is important to consider not only ecological aspects, but also socio-economic factors such as community empowerment and employment.

The concept of aquaculture carrying capacity (ECC), defined here as 'the amount of aquaculture production that can be supported without causing unacceptable changes to ecological processes, species, populations or communities in the environment', is not strictly applied in any jurisdiction's aquaculture policy documentation. A broader search has been undertaken to consider the concept of aquaculture carrying capacity (CC) more generally. Mangrove rehabilitation programmes are particularly important (Zhang et al., 2022).

Examples of ways to reduce adverse effects include compatibility with other uses, the presence of buffer zones, setting an appropriate balance between mangrove and pond area, improving pond design, reducing water turnover and increasing water residence time, and the size and ability to assimilate effluents from the water body (Zokaeifar et al., 2014). Increasing production, improving nutrition and food security while reducing land requirements and environmental impacts requires improved production systems to increase the carrying capacity of shrimp ponds.

1. Efficient and optimal feed management

Proper feed management also maintains optimal water quality for shrimp growth, reducing stress and the risk of disease.

2. Reducing Waste Accumulation in Ponds

Treating wastewater and recycling it through a process involving settling, sediment removal and aeration can return the water to the culture pond. (Zulfikar, 2023).

3. Increasing the dissolved oxygen (DO) value
4. Partial harvesting:

This is done to reduce the shrimp population in the pond. Once the population has been reduced, the oxygen consumption in the pond will decrease because there are fewer shrimp to consume oxygen through respiration.

Conclusion

The aquaculture land area in Banten Bay is 5,009.3 hectares, which can be divided into nine clusters based on land suitability and carrying capacity, taking into account the water supply. Nine of these clusters are suitable for shrimp farming. The land area that can be used for intensive ponds is 228.2 ha (0.045%), with a production capacity of 3,002.8 tonnes/ha/cycle. If managed semi-intensively, the area is 428.97 Ha; if managed extensively, the area is 5,004.66 Ha. The carrying capacity can be increased by reducing organic matter and changing cropping patterns, as well as by increasing dissolved oxygen.

Acknowledgements

The authors would like to thank all the researchers involved for their laboratory work and technical advice during the experiment. Jakarta Technical University of Fisheries, Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

Conflictofinterest:Theauthorsdeclarethattheyhavenoconflictofinterest.

References

[1]. Anjaini, J., Akhhila, N., Shafa, A.N., Hermawan, F.A, Sukaesih,D.I., Sitoru,s R,J.S., Setiawan, A,C.. (2024). Water quality management strategies to increase the productivity of white shrimp (*Litopenaeus vannamei)* culture. Journal of food and agriculture science. 2: 9-16.

[2]. Araujo,A. N, San Andres, C.F.S, Nguyen, K.Q., Corby, T,L., Rhodes, A.A, García, J., Luke, A., Roy, L,A., Davis, D,A. (2024) Effects of minimum dissolved oxygen setpoints for aeration in semi-intensive pond production of Pacific white shrimp (*Litopenaeus vannamei*) . Veterinary World;17(1):50–58. https://doi.org/10.14202/vetworld.2024.50-58

[3]. Ariadi, H., Wafi, A., Musa, M., Supriatna. (2021). Interrelationships of Water Quality Parameters in Intensive White Shrimp Farming (*Litopenaeus vannamei*). Journal of Fisheries Science. 12:18–28.

[4]. Arsad, S., Afandy, A., Purwadhi, A.P., Maya, V.B., Saputra, D.K., Buwono, N.R. (2017). Study of Vaname Shrimp (*Litopenaeus vannamei)* cultivation activities with the application of different maintenance systems. Scientific Journal of Fisheries and Marine. 9:1-14. https://doi.org/10.20473/jipk.v9i1.7624

[5]. Boyd, C.E. (1995) Bottom Soils, Sediment, and Pond Aquaculture. Chapman and Hall, New York. 348 pp.

[6]. Cooper, E.J., er, APOE., Graham, J.J., Mierau, D..W., Trush, WJ., Taylor,R. (2020) Salmonid habitat and population capacity estimates for steelhead trout and chinook salmon upstream of Scott dam in the Eel River, California. Northwest Sci. 94 70–96, https://doi.org/10.3955/046.094.0106.

[7]. Farkan M, Djokosetiyanto, D., Widjaja, R.S., Widiatmaka.,Kholil. (2017) Suitability of shrimp cultivation pond land with limiting factors in water quality, soil and infrastructure in Banten Bay, Indonesia. Jurnal Segara.13 (1):1-8.

[8]. Farkan, M., Novriadi, R., Sektiana, S.P., Lathifah, F., Margono, M., Ilhamdi, I., Maulita, M., Sumandiarsa, I.K. (2025). Analysis of Probiotic Application, Water Quality, Carrying Capacity and

Production of Penaeus vannamei Vaname Shrimp Culture in Ponds. Aquaculture Studies, 25(3), aquast2358. http://doi.org/10.4194/Aquast2358

[9]. Filgueira, R., Comeau, LA., Guyondet, T., McKindsey, CW., Byron, CJ., (2015). Modellingcarrying capacity of bivalve aquaculture: a review of definitions and methods, in: R.A. Meyers (Ed.), Encyclopediaof Sustainability Science and Technology,Springer New York, pp. 1–33. https://doi.org/10.1007/978-1-4939-2493-6_945-1

[10]. Hardjowigeno, S. (2002). Soil Science. Jakarta: Akademika Presindo

[11]. Hardjowigeno, S and Widiatmaka. 2007. Evaluasi kesesuaian lahan dan perencanaan tataguna lahan. Gajah Mada University Press. Yogyakarta. 352 hal.

[12]. Hemraj, D., Hossain, M., Ye, Q., Qin, J., Leterme, S. (2017).Plankton bioindicators of enviromental conditions in coastal lagoons. Estuarine, Coastal, and Shelf Science. 184: 102–114.

[13]. Hilborn, R., Walters,C.J,. Ludwig, D. (1995). Sustainable exploitation of renewableresources, Annu. Rev. Ecol. Syst. 26, 45–67, https://doi.org/10.1146/annurev.es.26.110195.000401.

[14]. Ismail, M., Abida, I.W., Wahyuni, E.T.(2022). Estimation of the carrying capacity of Pamekasan regency coastal waters in accepting Vannamei Shrimp farming waste. Proceedings Series on Physical & Formal Sciences, Volume 4 Proceedings of the National Seminar of the Faculty of Agriculture and Fisheries ISSN: 2808-7046, 83-89.

[15]. Islam, S.M.M., Siddik, M.A.B., Sørensen, M., Brinchmann, M.F., Thompson, K.D., Francis, D.S., Vatsos, I.N. (2024). Insect meal in aquafeeds: a sustainable path to enhanced mucosal immunity in fish. Fish. Shellfish Immunol. 150, 109625.

[16]. Jaffer, Y.D., Saraswathy, R., Ishfaq, M., Antony, J., Bundela, D.S, Sharm,a P.C., (2020). Effect of low salinity on the growth and survival of juvenile pacific white shrimp, Penaeus vannamei: A revival. Aquaculture, Elsevier. 2020;Volume 515, 15 January, 734561. https://doi.org/10.1016/j.aquaculture.2019.734561

[17]. Jefri, M., Satyantini., W. H., Sahidu, A. M., Nindarwi, D. D., Rozi. (2020). Application of Probiotics for Organic Matter and Enhancement of Growth Performance in White Shrimp (Litopenaeus vannamei). Scientific Journal of Fisheries and Marine, 12(1): 97-104. http://doi.org/10.20473/jipk.v12i1.16618

[18]. Krisnanta, A.D., Hasibuan, H.S., Tambunan, R.P.(2024). Analysis of landcover changes and carrying capacity of coastal cities North Javaof Central Java Province, Indonesia. Journal of Natural Resources and Environmental Management. 14 (1), 180-189, http://dx.doi.org/10.29244/jpsl.14.1.181

[19]. Link, J.S., Marshak, A.R. (2022). Ecosystem-Based Fisheries Management: Progress, Importance, and Impacts in the United States. Oxford University Press, 25 Jan 2022 - 678 pp.

[20]. Long, X., Yu, H., Sun, M.; Wang, X.C., Klemes, J.J.; Xie, W., Wang, C., Li, W. and Wang, Y. (2020). Sustainability evaluation based on the three-dimensional ecological footprint and human development index: A case study on the four island regions in China. Journal of Environmental Management, Volume 265, 110509. https://doi.org/10.1016/j.jenvman.110509.

[21]. Mintardjo, K. A., Sunaryanto,, Utaminingsih,. Hermiyaliningsih.(1984).Soil and water requirements. in aquaculture guidelines, Directorate General of Fisheries. Department of Agriculture Brackish Water Cultivation Centre. Jepara, 62 – 87 p.

[22]. Muir, J.F. and Kapetsky, J.M. (1988) Site selection decisions and project cost: the case of brackish water pond systems. In: Aquaculture Engineering Technologies for the Future. Hemisphere Publishing Corporation, New York.;p. 45--63.

[23]. Mustafa A, Paena M, Tarunamulia, Sammut J. (2008). Relationship between environmental condition factors and pond productivity to sharpen land suitability criteria: 2. Soil quality. J. Ris. Akuakultur.3:105-121.

[24]. Mustafa, M.F., Bunga, M., Achmad, M. (2019).Use of probiotics to suppress the population of Vibrio sp. Bacteria in Vaname Shrimp Farming (*Litopenaeus vannamei*). Journal of of Fisheries and Marine Science. 2:69–76.

[25]. Newell, R.I.E. (2007)A framework for developing ecological carrying capacity mathematical models for bivalve mollusc aquaculture, Bull. Fish. Res. Agency, 19 41–51. https://www.fra.affrc.go.jp/bulletin/bull/bull19/07.pdf. accessed August 2, 2022.

[26]. Rifalda, M.R., Robin, R., Novita, N. (2023). Evaluation of growth performance and water quality of vannamei shrimp (*Litopenaeus vannamei)* in intensive cultivation systems. Vol. 9 No. 2: 73-80. https://doi.org/10.30997/jmss.v9i2.8655

[27]. Ross, L.G., Telfer, T.C., Falconer, L., Soto, D., Aguilar-Manjarrez, J. (2013). Site selection and carrying capacities for inland and coastal aquaculture, in: FAO Fish. Aquac.Proc., Rome, FAO, Stirling, the United Kingdom of Great Britain and Northern Ireland,: p. 46. https://www.fao.org/3/i3099e/i3099e.pdf (accessedAugust 2, 2022).

[28]. Ross, S.R., McManus, I. C.1., Harrison, V., and Mason, O. (2013). Neurobehavioral problems following low-level exposure to organophosphate pesticides: a systematic and meta-analytic review. Critical Reviews in Toxicology, 2013; 43(1): 21–44 © 2013 Informa Healthcare USA, Inc. ISSN 1040-8444 print/ISSN 1547-6898 online DOI: 10.3109/10408444.2012.738645.

[29]. SNI 01-7246-2006. Production of Vaname Shrimp (Litopenaeus vannamei) in ponds with intensive technology. National Standardization Agency. Jakarta BSN. 2006

[30]. Supriatna., Mahmudia, M., Musa, M., Kusriania. (2020). PH Model and its relationship with water quality parameters in intensive vaname shrimp (Litopenaeus vannamei) ponds in Banyuwangi, East Java. JFMR-Journal of Fisheries and Marine Research.43:368–374.

[31]. Treece, G.D., Fox, J.M. (1999).Design, Operation and Training Manual for an Intensive Culture Shrimp Hatchery. Diane Publishing.

[32]. Ting, K.L., Kuo-Huan, K.L.L, Jhan, H.T., Huang ,T.J., Wang, C.M., Liu, W. (2015). Application Of sustainable fisheries development indocator system for taiwan aquaculture industry. Elsivier. 437.

[33]. Widigdo, B., dan J. Pariwono, 2003. Supportability of Waters in the North Coast of West Java for Shrimp Farming (Case Study in Subang, Jakarta Bay and Serang Districts), Indonesian Journal of Aquatic and Fisheries Sciences, 1: 10-17.

[34]. Weitzman, J., Filgueira, R., (2019). The evolution and application of carrying capacity in aquaculture: towards a research agenda. Reviews in Aquaculture. https://doi.org/10.1111/raq.12383.

[35]. Yunarty, Kurniaji, A., Budiyati., Renitasari, D.P., Resa, M. (2022). Water quality characteristics and growth performance of Vaname Shrimp Cultivation (Litopenaeus vannamei) Intensively. Pen Aquatics: Scientific Journal of Fisheries and Marine Affairs.21:75-88.

[36]. Zhang, G., Lu, Y., , Fang, Z., Yang, H., Wei, Z., (2022). Analysis of the Ecological Carrying Capacity of Fish Resources in Shengjin Lake, Anhui Province, China. Int J Environ Res Public Health. 2022 Jul 4;19(13):8177. doi: 10.3390/ijerph19138177

[37]. Zokaeifar, H., Babae,N., Saad, C., Kamarudin, M., Sijam, K., Balcazar, J. (2014). Administrations of Bacillus subtilis Strains in the Rearing Water Enhances The Water Quality, Growth Performance, Immune Response, and Resistance Against Vibrio harveyi Infection in Juvenile White Shirmp. J Fish and Shelflish Immunology.36:68–74.

[38]. Zulfikar, W.G. (2023). Probiotics: Maintaining shrimp health and water quality. Jala, https://jala.tech/id/blog/tips-budidaya/probiotik-menjaga-kesehatan-udang-dan-kualitas-air