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Ecological Study to Support the Productivity of Vaname Shrimp Cultivation in Lawallu Village, Barru Regency, South Sulawesi

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Abstrak: Soppeng Riaja Subdistrict is one of the coastal areas that has long been utilized for shrimp farming. Since 2007, vannamei shrimp (*Litopenaeus vannamei*) has been the most widely cultivated species. The biggest challenge faced by shrimp farmers in production is disease outbreaks. Diseases in shrimp cause a decline in shrimp quality and even mortality, which ultimately leads to economic losses and impacts the sustainability of shrimp farming operations. This study aims to evaluate the ecological aspects, including water conditions and carrying capacity, based on its ability to accommodate waste from shrimp farming in Lawallu Village, Soppeng Riaja Subdistrict, Barru Regency, South Sulawesi. The research was conducted from August to October 2023 using a quantitative approach. The findings reveal that vannamei shrimp production in Lawallu Village has been declining annually. In 2023, productivity was recorded at 438 tons, significantly below the sustainable pond productivity benchmark of 1008.9 tons per year. Despite the low productivity, the total shrimp farming area in Lawallu Village has reached 88.66 hectares, exceeding its ideal carrying capacity, which is only 44.84 hectares. Water quality analysis showed that ammonia levels in the shrimp pond waters of Lawallu Village have exceeded the quality standards. The adoption of sustainable aquaculture technology, effective water quality management, and proper wastewater management are essential strategies for achieving sustainable productivity.

Keywords: Carrying capacity; Vaname shrimp; Water quality

Introduction

South Sulawesi is the province with the highest shrimp production and the largest shrimp farming area in Indonesia, covering 98,617 hectares with a shrimp production output of 44,528 tons in 2019 (Badan Pusat Statistik, 2019). Barru Regency, located on the western coast of South Sulawesi, is recognized as the largest shrimp producer in the region (Yunita et al., 2022) with approximately 2,539 hectares of potential aquaculture ponds. Since 1980, Lawallu Village, part of the Soppeng Riaja District, has been utilized for black tiger shrimp (*Penaeus monodon*) farming, transitioning to whiteleg shrimp (*Litopenaeus vannamei*) farming in 2007. The village consists of three hamlets, two of which—Tanrabalan and Oring—engage in aquaculture activities. As of 2021, the total pond area in Barru Regency was 2,539.1 hectares, yielding 4,748.8 tons of whiteleg shrimp (Badan Pusat Statistik Provinsi Sulawesi Selatan, 2021).

The data obtained from the Lawallu Village Office indicates that 200 hectares of coastal areas have been

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converted from rice fields and mangrove ecosystems into aquaculture ponds, comprising 127 plots with a total area of 109 hectares. These include 17 intensive aquaculture plots producing approximately 20 tons of shrimp per hectare per cycle, 78 semi-intensive plots producing 2 tons per hectare, and 32 traditional plots yielding 0.5 tons per hectare per cycle. The production of vannamei shrimp in Lawallu Village reached 455.2 tons in 2017, increased to 610.3 tons in 2018, but declined to 230.2 tons in 2019 and 2020 (Badan Pusat Statistik Provinsi Sulawesi Selatan, 2021). The challenges in vannamei shrimp farming in Lawallu Village over the past two years have been disease outbreaks (Anderson et al., 2017), including viruses and bacteria, particularly Acute Hepatopancreatic Necrosis Disease (AHPND). According to shrimp pond technicians in Lawallu Village, this disease has been present since 2011 (Alfian, 2024).

Shrimp farming without effective management can lead to future problems. Ilman et al. (2009) research states that continuous shrimp cultivation in ponds degrades environmental quality, including water, biological ecosystems, and increases sediment levels. Consequently, declining environmental quality may result in crop failures (Wahyudi et al., 2022), as observed in various regions of Indonesia.

The common issues in shrimp pond management in Lawallu Village include production failure of vannamei shrimp due to *Vibrio parahaemolyticus* bacteria, which causes Acute Hepatopancreatic Necrosis Disease (AHPND). This disease typically affects shrimp 20–30 days after the larvae are stocked in the ponds (Anissa et al., 2023). Fluctuations in water quality are suspected to be the primary cause. Salinity concentrations are closely linked to the growth of *Vibrio* bacteria (Pariakan et al., 2023). The research conducted by Pariakan (2021) indicates that increasing water salinity concentrations tend to correlate with a higher number of bacteria in pond water. Furthermore, ammonia levels also influence the health, growth, and survival of whiteleg shrimp (*Litopenaeus vannamei*). Elevated ammonia concentrations can make aquatic organisms more susceptible to stress, potentially leading to mortality (Kathyayani et al., 2019). Exposure to ammonia concentrations can increase hemocyte apoptosis, which affects the immunity of whiteleg shrimp (*Litopenaeus vannamei*) (Liu et al., 2020).

The decline in carrying capacity due to continuous production activities that are not balanced with the preservation of coastal ecosystems in Lawallu Village has contributed to environmental degradation. The production of vannamei shrimp ponds generates significant waste, leading to a decline in pond productivity over the past three years. Water quality plays a crucial role in determining the survival and growth of shrimp in ponds (Farabi & Latuconsina, 2023). Based on these considerations, a comprehensive approach is required to analyze the relationships between water quality, environmental factors, and the carrying capacity of aquatic systems in relation to vannamei shrimp pond productivity (Wigiani et al., 2019). This approach seeks to integrate water quality parameters with environmental carrying capacity, which has not been extensively discussed in detail in the context of vannamei shrimp aquaculture in Indonesia's coastal regions, particularly in Lawallu Village.

The aim of this study is to assess the productivity of vannamei shrimp ponds and the carrying capacity of the surrounding waters, particularly in the coastal area of Lawallu Village, Soppeng Riaja District, Barru Regency. The results of this study are expected to provide data-driven guidance for sustainable shrimp pond management. Additionally, it can serve as a technical recommendation to maintain the sustainability of the coastal ecosystem as a supporting system for the pond ecosystem.

Method

Research Design

This study was conducted from August to October 2023, located in Tanrabalana Hamlet and Oring Hamlet, Lawallu Village, Soppeng Riaja District, Barru Regency, South Sulawesi Province. The selection of water quality sampling locations was based on their representation of vannamei shrimp farming activities, which can impact the coastal water quality. The study employed a quantitative approach, observing coastal characteristics including the presence of coastal ecosystems, tidal conditions, currents, substrate, and water quality measurements. The collected data were used as a basis for calculating the carrying capacity for further analysis. A flow diagram of the study is presented in Figure 1.

Sample and Data Collection

The data used in this study includes both primary and secondary data. The primary data observed includes water quality (ponds, channels, and seawater), and the bio-physical condition of the coastal area, such as beach slope and the distance for seawater intake for shrimp ponds during low tide. Water quality measurements were conducted once a month over a period of three months, in August, September, and October 2023. Tidal parameters and pond area width were obtained from the Fisheries Office of Barru Regency. The secondary data, including tidal patterns, pond area width, and vannamei shrimp production over the last three years, were also provided by the Fisheries Office of Barru Regency.

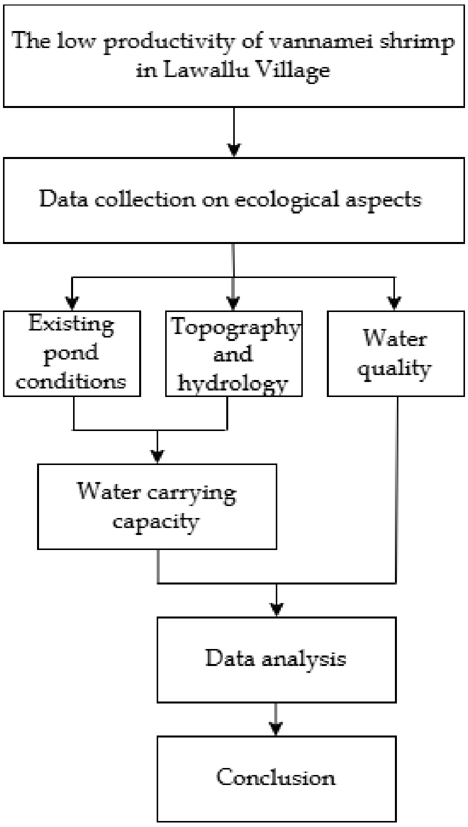

Figure 1. Flow diagram of the research

Data Analysis

The calculation of water carrying capacity is based on the method of available water in coastal waters to accommodate aquaculture pond waste. This method was developed by Widigdo & Pariwono (2003):

$$V_0 = 0.5\ hy\ (2x - \frac{h}{tg\theta}) \quad (1)$$

Description:
V_0 = Available volume of seawater (m^3) or volume of waters
h = Local tidal range (m)
y = The width of the pond area parallel to the coastline (m)
θ = Coastal slope angle (degrees)
X = Distance from the coastline (low tide) to the seawater intake location for pond needs (m)

If the tidal frequency is f times per day, then the total water volume (V_{0T}) for diluting waste is:

$$V_{0T} = f \times V_0 \quad (2)$$

After determining the total water volume (V_{0t}) , the volume of waste that can be accommodated by the water is one-hundredth of the water volume (Rakocy & Allison, 1981) s expressed in the following equation:

$$VL = \frac{V_{0T}}{100} \quad (3)$$

The replacement of pond water during maintenance is 10% per day (Boyd & Tucker, 1998), so the volume of waste is 10% of the total pond volume, as follows:

$$V_{pond} = V_{waste} \times 10 \quad (4)$$

The maximum area of the pond, assuming an average pond depth of 1 meter, is:

$$V_{pond} = L_{pond} \times t \quad (5)$$

Information:
V = Volume (m^3)
L = Area (m^2)
t = Water level in the pond (m)

The assumption for the comparison of the mapping of shrimp ponds and land for supporting infrastructure, including channels within a pond area, is 60:40, so the total area is:

$$L_{\text{total area}} = L_{pond} + \left[L_{pond} \times \frac{40}{60}\right] \quad (6)$$

The assumption of sustainable pond productivity is 7.5 tons/ha/MT (Boyd & Musig, 1992), so the environmental carrying capacity is:

$$CC = L_{pond} + 7.5 \quad (7)$$

Assuming 2.5 cropping seasons in 1 year, as commonly practiced by farmers, the carrying capacity for 1 year is:

$$= CC \times 2.5 \quad (8)$$

Result and Disscusion

General Condition of Shrimp Ponds in Lawallu Village

The waters of Lawallu Village are a semi-open beach facing the Makassar Strait, resulting in relatively strong waves. The current speed along the shoreline of the study area ranges from 0.02045 m/second to 0.05556 m/second. The tidal pattern is semi-diurnal, meaning that two high tides and two low tides occur within a 24-hour period. The substrate in the coastal area of Lawallu Village consists of mud-sandy and sandy-mud sediments. There are mangrove vegetation growing in the surrounding area, *Rhizopora apiculata,* and *Sonneratia alba.*

Lawallu Village is one of the coastal villages located in the Soppeng Riaja Subdistrict, where its coastal land is extensively used for vannamei shrimp farming. According to data from the Fisheries Department of Barru Regency over the past three years, the total area of shrimp ponds in Soppeng Riaja Subdistrict is 668 hectares, with no significant increase or decrease in land area. However, shrimp productivity in Soppeng Riaja Subdistrict has continuously declined by 29% over the past three years. In 2023, the total vannamei shrimp production in Soppeng Riaja Subdistrict was 1,079 tons, with 41% of this production, or 438 tons, coming from Lawallu Village, which covers an area of 88.66 hectares.

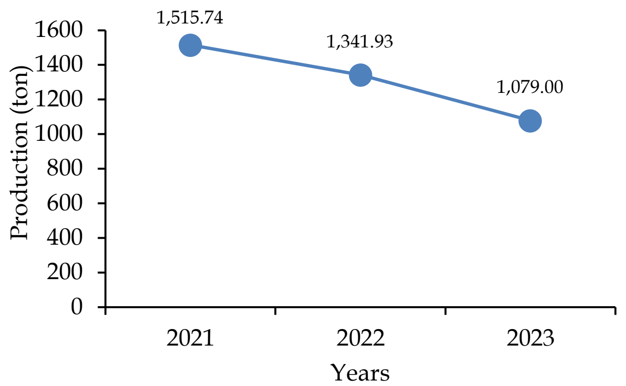

Figure 2. Vannamei Shrimp Production in Soppeng Riaja District from 2021 to 2023 (BPS Barru District 2023)

The productivity of shrimp is not only influenced by the size of the cultivation area but also by the technology used in farming. To date, 68% of shrimp farmers in Soppeng Riaja District still practice traditional or simple shrimp farming, 22% use semi-intensive technology, and 11% have adopted intensive technology.

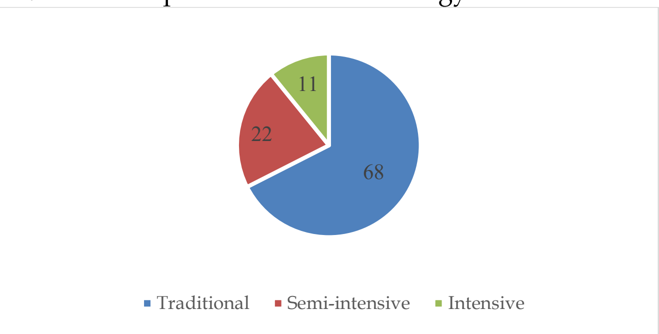

Figure 3. Percentage (%) of Vaname shrimp cultivation technology in Soppeng Riaja District (BPS Barru Regency 2023)

Based on data from the Fisheries Office of Barru Regency (DKP Barru Regency), the total area of shrimp ponds in Lawallu Village in 2023 was 89.64 ha. The number of active ponds is 84 out of a total of 105 (82% active). The shrimp ponds in Lawallu Village are located in two hamlets: Tanrabalana and Oring. The land area, number of farmers, and the number of ponds used for shrimp farming in Lawallu Village are presented in Table 1.

Based on Table 1, all of the farmers encountered in Lawallu Village have begun transitioning to semi-intensive and intensive technologies. The number of semi-intensive ponds is 88, accounting for 86% of the total vannamei shrimp ponds, while the number of intensive ponds is 17 (BPS Kab.Barru, 2023). The semi-intensive aquaculture practiced in Lawallu Village is based on land, with pond sizes ranging from 2,000 to 6,000 m². The stocking density in each pond ranges from 40,000 to 80,000 shrimp, with the use of one to two aerators per pond. Artificial feeding in the semi-intensive technology in Lawallu Village is applied once the shrimp begin to mature, and their plankton requirements decrease, with feeding frequency occurring three times a day.

Table 1. Land area, number of farmers, and number of ponds used in shrimp farming in Lawallu Village

Village	Pond area (Ha)	Number of farmers	Number of pond	
			Semi-Intensive	Intensive
Tanrabalana	31.44	40	34	8
Oring	58.2	57	54	9

(BPS Barru Regency, 2023)

In intensive aquaculture technology, most pond systems are made of concrete, with a small portion still using HDPE plastic. The size of intensive ponds is smaller, typically ranging from 2,000 to 3,000 m², with stocking densities ranging from 150,000 to 300,000 individuals per pond. The number of aerators used in intensive ponds typically ranges from 5 to 6 per pond. In intensive aquaculture, the feed used is entirely artificial, with feeding frequency occurring six times a day.

For both technologies, a pre-production phase was conducted, involving the preparation of containers, which lasted approximately 7 days. Water for aquaculture was sourced using a pump from a channel located in the surrounding coastal area. The water channels in Lawallu Village, in addition to serving as a water source, also act as disposal sites for waste generated from shrimp farming activities. Overall, the shrimp ponds in Lawallu Village discharge aquaculture waste directly into the surrounding water channels.

The shrimp cultivation period is typically around 90 days to minimize losses and harvest failures. Many harvest failures are caused by diseases that lead to shrimp mortality. Some of the shrimp diseases found in Lawallu Village are Acute Hepatopancreatic Necrosis Disease (AHPND) and White Spot Syndrome Virus (WSSV). The increasing vulnerability to the spread of these shrimp diseases is one of the reasons for reducing the number of shrimp fry released into each pond. Fluctuations and discrepancies in water quality standards for several parameters are contributing factors to the spread of shrimp diseases (Soto-Rodriguez et al., 2019). In addition to the numerous failures caused by disease outbreaks, the decline in shrimp production from 2019 to 2022 was indicated to be due to decreased market demand as a result of the Russia-Ukraine war and the impact of COVID-19 (Rachman, 2023).

Water Quality Measurement

The spread of shrimp diseases is determined by many biotic and abiotic factors that affect the health and productivity of shrimp farming. According to Supono (2018) one of the main causes of shrimp disease spread is environmental degradation of the ponds. A decline in environmental quality leads to the rapid proliferation of pathogens and harmful plankton. The organic waste produced in shrimp farming affects other water quality parameters, which can also influence the shrimp's resistance to disease infections.

Table 2. Water quality in water channels

Parameter	Station 1	Station 2	Station 3	Station 4	Minister of Maritime Affairs and Fisheries Regulation Number 75 Year 2016	
					Semi intensive	Intensive
Temperature (°C)	30.33 ± 0.15	30.37 ± 0.15	30.4 ± 0.20	30.33 ± 0.12	28 – 30	28 – 30
pH	8.3 ± 0.17	8.33 ± 0.06	8.37 ± 0.12	8.2 ± 0.2	7.5 – 8.5	7.5 – 8.5
Salinity (%)	34.67 ± 2.31	35.33 ± 1.15	35 ± 1.73	39.67 ± 3.79	10 – 35	26 – 32
Dissolved Oxygen (mg/L)	7.2 ± 0.57	7.3 ± 0.17	7.1 ± 0.20	6.9 ± 0.46	> 3	> 4
Water transparency (cm)	40 ± 2.65	40.67 ± 2.31	40.67 ± 3.21	40 ± 3.46	30 – 45	30 – 50
TSS (mg/L)	44 ± 9.64	46 ± 7.94	44.33 ± 4.04	50 ± 3	150 – 200	–
Alkalinity (mg/L)	122.67 ± 4.16	120.33 ± 4.93	120.67 ± 3.51	132.33 ± 4.51	80 – 150	100 – 150
Ammonia (mg/L)	0.245 ± 0.090	0.269 ± 0.053	0.224 ± 0.062	0.268 ± 0.094	< 0.01	≤ 0.1

Table 3. Water quality of waters and pond

Parameter	Water Quality of Waters	Goverment Regulation Number 22 Year 2021	Shrimp Pond		Minister of Maritime Affairs and Fisheries Regulation Number 75 Year 2016	
			Semi Intensive	Intensive	Semi Intensive	Intensive
Temperature (°C)	30.27 ± 0.15	28 – 32	28.53 ± 0.21	28.77 ± 0.15	28 – 31.5	> 27
pH	7.43 ± 0.25	7 – 8.5	8.3 ± 0.17	8.5 ± 0.17	7.5 – 8.5	7.5 – 8.5
Salinity (%)	27.33 ± 0.58	33 – 34	33.33 ± 0.58	34.67 ± 1.53	10 – 35	26 – 32
Dissolved Oxygen (mg/L)	7.93 ± 0.12	> 5	6.73 ± 0.12	6.47 ± 0.32	> 3	> 4
Water Transparency (cm)	–	–	31 ± 2.65	36.67 ± 8.96	20 – 45	30 – 50
TSS (mg/L)	20 ± 2	80	44.67 ± 14.50	61.33 ± 16.04	–	–
Alkalinity (mg/L)	111.67 ± 14.43	–	107.33 ± 17.21	132.67 ± 15.53	100 – 150	100 – 150
Ammonia (mg/L)	0.199 ± 0.15	0.3	0.583 ± 0.853	1.44 ± 1.08	< 0.1	≤ 0.1

Based on the Minister of Marine Affairs and Fisheries Regulation No. 75 of 2016 concerning the water quality requirements for aquaculture and water management for pond maintenance, the parameters exceeding the quality standards are salinity and ammonia. The six water quality parameters studied—temperature, pH, dissolved oxygen (DO), turbidity, TSS, and alkalinity—according to Tables 2 and 3, are still in accordance with the requirements for water quality in aquaculture sources and pond maintenance. According to Supono (2018), temperature, pH, and dissolved oxygen significantly affect shrimp growth and survival. These three factors are key in influencing the shrimp's appetite, metabolism, and growth.

The pH value in aquatic environments is influenced by the presence of carbon dioxide (CO_2) resulting from respiration, decomposition, or diffusion from the air. Waters with high CO_2 levels typically have a low pH or acidic conditions. This occurs because the presence of CO_2 in water triggers an increase in hydrogen ion concentration, which can lower the pH and make it more acidic. Additionally, temperature also affects pH. Temperature variations influence the solubility of carbon dioxide, where higher temperatures reduce carbon dioxide solubility, causing the pH to increase (Supriatna et al., 2020)

Alkalinity also influences water fertility as it can reduce pH fluctuations during day and night and plays a role in the biosynthesis of aquatic plants. Alkalinity acts as a buffer against acidity. Measuring water quality parameters in shrimp ponds is crucial for evaluating the total alkalinity values in aquaculture waters. The alkalinity values obtained from semi-intensive and intensive ponds comply with the standards outlined in Regulation of the Minister of Marine Affairs and Fisheries No. 75 of 2016 regarding water quality requirements for cultivation ponds. Low alkalinity levels can cause shrimp to undergo abnormal molting or frequent shell changes (Listriyana et al., 2023).

The salinity values in the water channels are higher than the recommended reference in the Ministerial Regulation of Maritime Affairs and Fisheries (Permen KP) 2016, where the maximum water quality for source water is set at 35 for semi-intensive ponds and 32 for intensive ponds (Table 2). According to Fegan (2003), vannamei shrimp are euryhaline, meaning they can survive within a wide salinity range of 2 to 40 ppt. This salinity range is therefore tolerable and suitable for use as a water source in vannamei shrimp aquaculture. However, in the pond water (Table 3), the salinity values are considered appropriate due to prior treatment to adjust the water quality suitable for shrimp habitat. Salinity is an important aspect of water quality as it affects the growth of vannamei shrimp. Salinity plays a role in osmoregulation and molting in shrimp. Both high salinity (hyperosmotic) and low salinity (hypoosmotic) can disrupt shrimp growth due to interference with the osmoregulatory process (Salsabiela, 2020).

The DO values obtained from the four locations are still acceptable, as they are above 3 mg/L for semi-intensive ponds and above 4 mg/L for intensive ponds. The higher the DO level in the water, the better the water quality. In shrimp farming, to maintain salinity and dissolved oxygen levels within acceptable limits, aerators must be activated to sustain optimal temperatures. DO levels will decrease if BOD and organic matter increase (Palani et al., 2020)

Furthermore, turbidity and TSS are related to the turbidity caused by the presence of suspended solids and substances in the water. The turbidity is also still in accordance with the requirements for vannamei shrimp pond maintenance. This is further supported by Santhosh & Singh (2017) which states that a turbidity range of 30-40 cm represents optimum pond productivity for shrimp cultivation. According to Gaona et al. (2017), TSS levels that can still be tolerated for vannamei shrimp life range between 100-300 mg/l. The low TSS values in the water channels can be attributed to the coastal characteristics of Lawallu Village, which has a relatively high tidal range of approximately 1.1 meters with a mixed, predominantly semi-diurnal tide type. According to Rizaki et al., (2022) this means there are typically two high tides and two low tides within a day, although occasionally, there may be only one tidal cycle with varying heights. According to Mustofa (2017) TSS is one of the indicators of water pollution that needs to be monitored in aquaculture activities. Approximately 35% of the feed given to shrimp in ponds will enter the water as TSS. As the pond ages, the residual feed and shrimp waste content will increase and accumulate in the pond water.

For ammonia parameters, both in the water channels and the ponds, the values have exceeded the quality standards. When compared to Government Regulation Number 22 of 2021, the ammonia levels in the waters of Lawallu Village have also surpassed the established quality standards. Ammonia is a chemical compound composed of nitrogen atoms, used as an indicator of organic pollution in aquatic environments. Ammonia in water results from the breakdown of organic nitrogen from proteins and urea, as well as inorganic nitrogen from the decomposition of dead organic matter, such as plants and marine organisms, by microbes and fungi through the process of ammonification (Kurniawan et al., 2022). According to Azizah & Humairoh (2017), the presence of ammonia in water above the threshold limit can disrupt aquatic ecosystems and other living organisms. Ammonia is highly toxic to almost all organisms. The main source of ammonia in shrimp ponds comes from shrimp excretion and the accumulation of organic matter from leftover feed and dead plankton. In its metabolism, shrimp utilize protein as an energy source and excrete ammonia as a byproduct. The high protein content in the feed significantly contributes to the accumulation of organic nitrogen compounds in the pond, which then undergoes ammonification into ammonia (Sahrijanna & Sahabuddin, 2014). Amonia yang tinggi dapat menyebabkan kematian, merusak insang menurunnya kemampuan darah dalam transportasi oksigen, dan mudah terserang penyakit (Supono, 2015).

Regional Carrying Capacity Based on Water Volume Availability

The relationship between carrying capacity and water quality is measured by the crucial role of water quality in determining the carrying capacity of a water body. Carrying capacity refers to the ability of the aquatic ecosystem to support the life of aquatic organisms, including shrimp. The carrying capacity of water can also be interpreted as the ability of the water to assimilate organic waste without contaminating the water, thus maintaining ecological balance (Widigdo et al., 2000). The data required to calculate the carrying capacity based on the research findings are presented in Table 4.

Table 4. Physical condition of Lawallu Village waters

Parameter	Result	Unit
Tidal range (h)	1.1	Meter
Length of pond area parallel to the coastline (y)	6408	Meter
Slope of beach (θ)	3	(%)
Distance from the coastline to the seawater intake location (X)	400	Meter
Tidal frequency (f)	2	Time

Based on the calculation of the available water volume on the coast (Vo), a value of 2,690,280.25 m^3 was obtained, and the available water volume per day (VOT) is 5,380,560.5 m^3 (occurring during two tidal cycles). The volume of waste that can be accommodated in the water is one-hundredth of the total water volume (VOT), which equals 53,805 m^3/day, resulting from a 10% replacement of the pond volume. Therefore, the maximum pond volume is 538,056 m^3. The average pond depth in Lawallu Village is 1.2 meters, so the maximum pond area that can be supported is 44.84 hectares. According to Boyd & Musig (1992), the maximum feed that can be provided to maintain the sustainability of the shrimp pond is 150 kg/day, with a percentage of 2 – 2.5% of the shrimp biomass as it approaches harvest. Thus, the estimated shrimp productivity ranges from 6 – 7.5 tons/Ha/MT.

Based on these values, the sustainable shrimp productivity for the Lawallu Village pond area of 44.84 ha/MT is 336.3 tons/MT or 1008.9 tons/year, as there are 3 cultivation cycles per year. This result is then compared with field data, where the total existing pond area in Lawallu Village is 89.64 ha, and the productivity in 2023 was 438 tons. This indicates that the total pond area in Lawallu Village has already exceeded the ideal pond size by twice, but the productivity achieved is still below the ideal productivity.

According to Anas et al. (2015), the carrying capacity of a region is not static; it can decline due to human activities that produce waste or environmental damage, such as natural disasters. However, it can also be enhanced through proper management of the area to improve its carrying capacity, supporting aquaculture activities and increasing the productivity of vannamei shrimp in Lawallu Village. A decrease in carrying capacity can reduce water quality, which in turn facilitates the development of shrimp diseases, leading to a decline in production. Carrying capacity serves as a limit in aquaculture, related to the capacity of an area to absorb or dispose of waste from the existing aquaculture activities in that area.

In the case of Lawallu Village, the land area does not need to be expanded; however, the existing land needs to be further optimized through several approaches, including the use of high-quality or SPF-certified post-larvae and the application of safe, regulated feed to achieve an ideal feed conversion ratio (FCR). This is supported by research conducted by Husain et al. (2020) which explains that Lawallu Village has a high feasibility for the development of vannamei shrimp farming. However, some innovations and policies are needed for its development. Key policies and strategies include improving the Good Aquaculture Practices (CBIB) to increase production volume and maintain quality, as well as optimizing technology for shrimp farming. In practice, water quality management and wastewater treatment before discharge into open waters should also be implemented to enhance the carrying capacity of the area, which could support increased shrimp productivity in Lawallu Village. Some treatments for aquaculture waste include creating settling ponds/channels for waste and utilizing the waste to produce fertilizer for surrounding plants.

Conclusion

The productivity of vannamei shrimp in Lawallu Village has decreased by nearly 20%, with a total of 438 tons in 2023. Based on the calculation of the carrying capacity of the surrounding waters, the area of shrimp ponds in Lawallu Village has now exceeded twice the ideal land area, which is only 44.84 hectares. However, the productivity for 2023 is still below the sustainable pond productivity, which can reach 1008.9 tons per year. There is a need to enhance the carrying capacity and use environmentally friendly technologies to improve shrimp productivity in Lawallu Village.

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Author Contributions

Conceptualization, A., B.W., S.H.; data curation A.N.K., A.R.U.; methodology, formal analysis, writing-original draft preparation, and visualization, A., A.N.K., A.R.U; validation and supervision B.W., S.H., translator A.H. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Alfian. (2024). *Pengelolaan Kawasan Pesisir Untuk Pengembangan Tambak Udang Vaname (Studi Kasus: Desa Lawallu, Kecamatan Soppeng Riaja, Kabupaten Barru)*. Scientific repository IPB. Retrieved from https://repository.ipb.ac.id/handle/123456789/155737

Anas, P., Sudinno, D., & Jubaedah, I. (2015). Daya Dukung Perairan Untuk Budidaya Udang Vannamei Sistim Semi Intensif Dalam Pemanfaatan Wilayah Pesisir Kabupaten

Pemalang. *Jurnal Penyuluhan Perikanan Dan Kelautan*, *9*(2), 29–46. https://doi.org/10.33378/jppik.v9i2.61

Anderson, J. L., Valderrama, D., & Jory, D. (2017). Shrimp Aquaculture Production by World Region : 2000-2017. *Global Aquaculture Alliance*, 1–54. Retrieved from https://www.aquaculturealliance.org/wp-content/uploads/2018/01/Global-Shrimp-Production-Data-Analysis-Dr.-James-Anderson-GOAL-2017.pdf

Anissa, R. K., Lisdiana, L., & Widyayanti, A. T. (2023). Optimasi Metode Nested PCR untuk Deteksi Vibrio parahaemolyticus AHPND pada Udang Vaname (Litopenaeus vannamei). *LenteraBio : Berkala Ilmiah Biologi*, *13*(1), 1–13. https://doi.org/10.26740/lenterabio.v13n1.p1-13

Azizah, M., & Humairoh, M. (2017). Analisis Kadar Amonia (NH3) Dalam Air Di Sungai Cileungsi. *Jurnal Nusa Sylva*, *15*(1 SE-Articles), 47–54. https://doi.org/10.31938/jns.v15i1.132

Santhosh, B., & Singh, N. P. (2017). Guidelines for water quality management for fish culture in Tripura. *ICAR research complex for NEH region, Tripura center, publication*, *29*(10). Retrieved from https://shorturl.asia/BQuDA

Badan Pusat Statistik. (2019). *Kabupaten Barru Dalam Angka 2019*. 1–14. Retrieved from https://shorturl.asia/hYCVE

Badan Pusat Statistik Provinsi Sulawesi Selatan. (2021). *Statistik Daerah Provinsi Sulawesi Selatan*. Retrieved from https://shorturl.asia/EAien

Boyd, Claude E; Tucker, C. S. (1998). *Pound Aquaculture Water Quality Management*. Springer Science & Business Media.

Boyd, C. E., & Musig, Y. (1992). Shrimp pond effluents: observations of the nature of the problem on commercial farms. *Proceedings of the Special Session on Shrimp Farming*, 195–197. Retrieved from https://shorturl.asia/HFQN8

BPS Kab.Barru. (2023). *Kabupaten Barru Dalam Angka 2023*. Retrieved from https://barrukab.bps.go.id/id/publication/2023/02/28/48f5efa57757d78168a8d408/kabupaten-barru-dalam-angka-2023.html

Farabi, A. I., & Latuconsina, H. (2023). Manajemen Kualitas Air pada Pembesaran Udang Vaname (Litopenaeus vannamei) di UPT. BAPL (Budidaya Air Payau dan Laut) Bangil Pasuruan Jawa Timur. *Jurnal Riset Perikanan Dan Kelautan*, *5*(1), 1–13. https://doi.org/10.33506/jrpk.v5ii.2097

Fegan, D. F. (2003). Budidaya Udang Vannamei (Litopenaeus vannamei) di Asia. *Gold Coin Indonesia Specialities Jakarta*. Retrieved from https://shorturl.asia/jg25G

Gaona, C. A. P., de Almeida, M. S., Viau, V., Poersch, L. H., & Wasielesky, W. (2017). Effect of different total suspended solids levels on a Litopenaeus vannamei (Boone, 1931) BFT culture system during biofloc formation. *Aquaculture Research*, *48*(3), 1070–1079. https://doi.org/10.1111/are.12949

Husain, N., Rustam, R., & Rauf, A. (2020). Strategi Pengembangan Usaha Budidaya Tambak Yang Berkelanjutan Di Desa Lawallu Kabupaten Barru. *Journal of Indonesian Tropical Fisheries (JOINT-FISH) : Jurnal Akuakultur, Teknologi Dan Manajemen Perikanan Tangkap, Ilmu Kelautan*, *3*(2), 138–150. https://doi.org/10.33096/joint-fish.v3i2.73

Ilman, M., Conservancy, T. N., Wiharyanto, D., Tarakan, U. B., & Desyana, C. (2009). Keunikan dan Peluang Revitalisasi Perikanan Tambak Udang di Wilayah Pesisir Utara Kalimantan Timur. *WWF Indonesia*. Retrieved from https://shorturl.asia/1FN3Z

Kathyayani, S. A., Poornima, M., Sukumaran, S., Nagavel, A., & Muralidhar, M. (2019). Effect of ammonia stress on immune variables of Pacific white shrimp Penaeus vannamei under varying levels of pH and susceptibility to white spot syndrome virus. *Ecotoxicology and Environmental Safety*, *184*, 109626. https://doi.org/https://doi.org/10.1016/j.ecoenv.2019.109626

Kurniawan, I., Sholeh, A., & Mariadi, P. D. (2022). Pemeriksaan Amonia dalam Air Menggunakan Metode Fenat dengan VariasiSuhu dan Waktu Inkubasi. *Gunung Djati Conference Series*, *7*, 77–82. Retrieved from https://conferences.uinsgd.ac.id/index.php/

Listriyana, A., Handayani, C., & Diah Pahlewi, A. (2023). Analisis Kualitas Air Alkalinitas pada Perairan Tambak Intensif Situbondo. *Zona Laut Jurnal Inovasi Sains Dan Teknologi Kelautan*, *4*(2), 159–164. https://doi.org/10.62012/zl.v4i2.27456

Liu, F., Li, S., Yu, Y., Sun, M., Xiang, J., & Li, F. (2020). Effects of ammonia stress on the hemocytes of the Pacific white shrimp Litopenaeus vannamei. *Chemosphere*, *239*, 124759. https://doi.org/10.1016/j.chemosphere.2019.124759

Mustofa, A. (2017). Kandungan Total Zat Padat Tersuspensi dari Outlet TTambak Udang Intensif di Kabupaten Jepara. *Jurnal Disprotek*, *8*(1), 34–45. https://doi.org/10.34001/jdpt.v8i1.484

Palani, S. R., Balasubramaniyan, K., & Durairaj, D. (2020). Fuzzy classifier model to know the sustainability of aquatic organisms and to forecast the aqua farmers. *Environmental Science and Pollution Research*, *27*(21), 26463–26472.

https://doi.org/10.1007/s11356-020-08489-7

Pariakan, A. (2021). Karakteristik Kualitas Air Dan Keberadaan Bakteri Vibrio Sp. Pada Wilayah Tambak Udang Tradisional Di Pesisir Wundulako Dan Pomalaa Kolaka. *JFMR-Journal of Fisheries and Marine Research*, *5*(3), 547–556. https://doi.org/10.21776/ub.jfmr.2021.005.03.5

Pariakan, A., Rahim, R., & Indrayani, I. (2023). Pola Hubungan Salinitas, Oksigen Terlarut dan pH Terhadap Bakteri Vibrio sp. pada Lokasi Budidaya Udang (Litopenaeus vannamei) di Kabupaten Kolaka. *Samakia : Jurnal Ilmu Perikanan*, *14*(2), 119–128. https://doi.org/10.35316/jsapi.v14i2.2654

Rachman, M. A. (2023). Analisis Keterbukaan Ekonomi Dan Ekspor Di Indonesia: Studi Empiris Pada Dampak Covid-19 Dan Peperangan Rusia-Ukraina. *BISECER (Business Economic Entrepreneurship)*, *6*(1), 38. https://doi.org/10.61689/bisecer.v6i1.423

Rakocy, J. E., & Allison, R. (1981). *Evaluation of a closed recirculating system for the culture of Tilapia and aquatic macrophytes.* https://doi.org/10.5555/19822415133

Rizaki, I., Hariyadi, S., & Arifin, T. (2022). The Characteristics of Marine Environment and Suitability For Pearl Oyster (Pinctada Maxima) Cultivation in Barru Regency. *Coastal and Ocean Journal (COJ)*, *5*(1), 37–53. https://doi.org/10.29244/coj.5.1.37-53

Sahrijanna, A., & Sahabuddin, S. (2014). Kajian Kualitas Air pada Budidaya Udang Vaname (Litopenaeus vannamei) dengan Sistem Pergiliran Pakan di Tambak Intensif. *Prosiding Forum Inovasi Teknologi Akuakultur*, 313–320. Retrieved from https://ejournal-balitbang.kkp.go.id/index.php/fita/article/view/3060

Salsabiela, M. (2020). Pengaruh Tingkat Salinitas Berbeda Terhadap Pertumbuhan Udang Vannamei (Litopenaeus Vannamei) Yang Diablasi. *Jurnal Indonesia Sosial Teknologi*, *1*(05 SE-Articles), 405–413. https://doi.org/10.59141/jist.v1i05.49

Soto-Rodriguez, S. A., Lozano-Olvera, R., Palacios-Gonzalez, D. A., Bolan-Mejia, C., & Rendon-Aguilar, K. G. (2019). Characterization and growth conditions of strains with different virulence degrees that cause acute hepatopancreatic necrosis disease in. *Journal of the World Aquaculture Society*, *50*(5), 1002–1015. https://doi.org/https://doi.org/10.1111/jwas.12617

Supono, S. (2015). *Manajemen Lingkungan untuk akuakultur*. Plantaxia. Retrieved from http://repository.lppm.unila.ac.id/id/eprint/3654

Supono, S. (2018). *Manajemen kualitas air untuk budidaya udang*. Aura. Retrieved from http://repository.lppm.unila.ac.id/id/eprint/14543

Supriatna, S., Mahmudi, M., Musa, M., & Kusriani, K. (2020). Hubungan pH Dengan Parameter Kualitas Air Pada Tambak Intesif Udang Vannamei (Litopenaeus vannamei). *JFMR-Journal of Fisheries and Marine Research*, *4*(3), 368–374. https://doi.org/10.21776/ub.jfmr.2020.004.03.8

Wahyudi, D., Prihutomo, A., & Mukhlis, A. (2022). Produktivitas Budidaya Udang Vaname (Litopenaeus Vannamei) Super Intensif Di Bak Terpal Bundar Dengan Padat Tebar Berbeda. *Jurnal Perikanan Unram*, *12*(4), 781–793. https://doi.org/10.29303/jp.v12i4.412

Widigdo, B., Kaswadji, R. F., Pariwono, J. I., Hariyadi, A. D., Patria, A. D., Rakasiwi, G., Taurusman, A. A., & Imran, Z. (2000). Penyusunan Kriteria Ekobiologis untuk Pemulihan dan Pelestarian Kawasan Pesisir di Pantura Jawa Barat. *Laporan Akhir. Kerjasama PKSPL-IPB Dan Dirjen Urusan Pesisir Pantai Dan Pulau Kecil, DKP*. Retrieved foem https://shorturl.asia/gy6Xf

Widigdo, B., & Pariwono, J. (2003). Daya dukung perairan di pantai utara Jawa Barat untuk budidaya udang (Studi kasus di Kabupaten Subang, Teluk Jakarta dan Serang). *Jurnal Ilmu-Ilmu Perairan Dan Perikanan Indonesia*, *10*(1), 10–17. Retrieved from https://shorturl.asia/Wi5LV

Wigiani, D. P., Widigdo, B., Soewardi, K., & Taryono. (2019). Status Keberlanjutan Kawasan Pesisir Berbasis Budidaya Udang Vaname Di Kecamatan Indramayu. *JFMR-Journal of Fisheries and Marine Research*, *3*(2), 18–28. https://doi.org/10.21776/ub.jfmr.2019.003.02.3

Yunita, R., Pratiwi, S. F., Pambudi, B. P., & Rakuasa, H. (2022). Evaluasi Kesesuaian Lahan untuk Budidaya Perikanan Tambak Terhadap Rencana Pola Ruang di Kabupaten Barru Provinsi Sulawesi Selatan. *Jurnal Geografi : Media Informasi Pengembangan Dan Profesi Kegeografian*, *19*(1), 10–17. https://doi.org/10.15294/jg.v19i1.32201