JPPIPA 11(12) (2025)

Jurnal Penelitian Pendidikan IPA

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Sustainability Status of Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency

Destrina Elita Koto[1*], Asus Maizar Suryanto Hertika[2], Jati Batoro[3]

[1] Master Program of Enviromental Management & Development Brawijaya University Malang, Malang, Indonesia.
[2] Faculty of Fisheries and Marine Science Brawijaya University Malang, Malang, Indonesia.
[3] Faculty of Mathematics and Natural Sciences Brawijaya University Malang, Malang, Indonesia.

Received: October 10, 2025
Revised: November 14, 2025
Accepted: December 29, 2025
Published: December 31, 2025

Corresponding Author:
Destrina Elita Koto
elitadestrina@student.ub.ac.id

DOI: 10.29303/jppipa.v11i12.13419

Abstract: Lamongan Regency was the largest center of the fisheries in East Java. Lamongan Regency only has two type of operation ponds: traditional brackishwater pond and semi-intensive brackishwater pond. Aquaculture in Lamongan District still relies on traditional fisheries. Whiteleg shrimp (*Penaeus vannamei*) as a Indonesia`s leading aquaculture commodities can have a positive impact on coastal communities, especially in economic and social aspects but does not have sustainable waste management. In this study, a multidimensional scalling (MDS) method was used to analyze the ecological, economi, social, technology and institutional dimension. The study was conducted during February – May 2025, primary data collection was carried out throught interview respondens and the secondary data from related data references. The result of the study showed that the sustainability values range both 48,57 – 55,82 (ecological dimensions), 60,83 – 67,60 (economic dimensions), 55,48-66,70 (social dimensions), 54,79 – 57,57 (technological dimensions), and 50,83 – 57,90 (institutional dimensions). The averages value of sustainability index of vaname shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency was quite sustainability. Based on leverage analysis, sensitive attributes obtained in this study were ecological dimensions (1) influence are the level of pollution, (2) pest attacks and (3) water quality management, economic dimension (1) availability of capital resources, (2) marketing prices (RMS = 4.0), and (3) impact on income , social dimension (1) interaction patterns, (2) training and socialization and (3) cultivation knowledge technological dimensions (1) wastewater treatment plant (WWTP) technology, (2) machine automation, and (3) the availability of facilities and infrastructure, and institutional dimensions (1) monitoring and evaluation

Keywords: Coastal Area; *Penaeus Vannamei*; Sustainability Status

Introduction

Lamongan Regency was the largest center of the fisheries in East Java. Fishing activies that utilized a 47 km coastline area and contributed to a production value of Rp. 1.333.631,915 (Kementerian Kelautan dan Perikanan [KKP], 2023). In 2022, this area will have a cultivation utilization of 20,487.40 hectares consist of ponds, rice fields, floating net cages and stepped net cages with a production of 62,754.85 tons and total value Rp. 1,577,347,888,000. This value was produced from the production of various commodities in aquaculture sector from types of freshwater fish, included shrimp and seaweed commodities (Kementerian Kelautan dan Perikanan [KKP], 2022). Lamongan Regency only has two type of operation ponds: traditional brackishwater pond and semi-intensive brackishwater pond. Traditional brackishwater pond in 2022 produced 3,081 tons and valued in Rp. 152.306.902 while semi-intensive brackishwater ponds produced 219 tond with valued 15,876,303 (BPS, 2022). This data shows that aquaculture in Lamongan District still relies on traditional fisheries.

Whiteleg shrimp (*Penaeus vannamei*) as a Indonesia`s leading aquaculture commodities

How to Cite:
Koto, D. E., Hertika, A. M. S., & Batoro, J. (2025). Sustainability Status of Vaname Shrimp (Penaeus vannamei) Pond in Coastal Areas of Lamongan Regency. *Jurnal Penelitian Pendidikan IPA*, *11*(12), 790-801. https://doi.org/10.29303/jppipa.v11i12.13419

contributed US$ 567 million in export activities from January – April 2023 (Imam, 2022). In Lamogan Regency, production of Whiteleg shrimp (*Penaeus vannamei*) reached 17,046.65 (Kelautan & Perikanan, 2021). Therefore, this commodity can have a positive impact on coastal communities, especially in economic and social aspects (Farabi et al., 2023). This is in line with statement (Oliveira et al., 2025) that aquaculture activities will result to increased demand for healty and nutritious food, which will drive increased social benefit (Pereira et al., 2021) for the community`s economy, especially in the areas of income and employment opportunities for the surrounding community, education, health, and even housing facilities. Howeever, the increasing of the demand for this commodity has the potential to reduce environmental aspects, especially in ponds that still used the traditional systems. This is because several water quality variables, which are important variables in whiteleg shrimp (*Penaeus vannamei*) ponds, have a negative contribution to environmental pollution caused by adequate pond waste disposal management (Isman et al., 2022).

Waste management in shrimp farming should be a concern for stakeholders from entrepreneurs, local communities both local and central governments to maintain the sustainability of aquaculture (Chen et al. 2023). Sustainable fishiries in aquaculture terms are generally defined as "sustainability". That defined as the utilization of aquaculture aimed at meeting the needs of the current generation while simultaneously ensuring the availability the these resources for used by future generations (Brundtland, 2017). The requirements for sustainable aquaculture must not damage the environment, comply with the intended technical requirements, and be economically and socially beneficial and acceptable to the surrounding community. Fauzi et al. (2002) describe five dimensions in sustainable fisheries management: ecological, economic, social, technological, and institutional. To improve the sustainability of whiteleg shrimp ponds, a management strategy is needed that focuses on improving the shrimp pond intensification system by increasing stocking density, improving water quality through continuous monitoring, improving disease management, and ensuring the appropriate use of pollutant-free probiotics, as well as ensuring adequate electricity supply (Nurdiansyah & Rosmiati, 2020). Furthermore, Airawati et al. (2023) in their research, also noted the need for strengthening the legal and institutional dimensions of whiteleg shrimp pond cultivation, particularly regarding pond land status and effective and simple waste management. A cluster-based management approach is necessary if there are differences in the sustainability status of traditional and intensive shrimp ponds (Wigiani, 2019).

Paciran Distric is one of the vaname shrimp *(Penaeus vannamei)* ponds that is starting to develop in Lamongan Regency, particularly in coastal areas, which borders the Java Sea to the north, Panceng District, Gresik Regency to the east, and Solokuro.

District to the south. By 2023, Paciran District had a pond area of 674,000 m^3, with seven potential villages (Fisheries, 2023). Despite its significant potential, particularly in the economic and social sectors of coastal communities, vaname shrimp *(Penaeus vannamei)* cultivation in Lamongan faces various challenges that deserve the attention of relevant stakeholders.

Based on the results of the researcher's observations, the location of the whiteleg shrimp pond *(Penaeus vannamei*) still does not have sustainable waste management, the remaining waste from the pond is dumped directly into nearby waters without prior filtering, including shrimp waste that is left scattered around the pond, this is due to the low awareness of the farmers regarding the environmental impacts caused by the management of whiteleg shrimp pond waste *(Penaeus vannamei*) (Krummenauer et al. 2011). This triggers the potential for disease attacks such as White Spot and Early Mortality Syndrome (EMS) in shrimp, this has long-term effects on fishery biota and ecosystems. In addition, the lack of supervision and law enforcement from the authorities related to waste management makes the farmers feel safe (Ahmed et al. 2017). Water quality measurements are still carried out manually based on knowledge and experience from observations without using water quality parameter measurement tools. The number and level of education of workers also affect the sustainability of whiteleg shrimp pond cultivation *(Penaeus vannamei)* (Zhou et al. 2012).

This situation does not meet the requirements for sustainable aquaculture, as defined by the Food and Agriculture Organization (FAO), which states that ponds must not harm the environment, be technically operational, and have positive economic and social impacts that are acceptable to the surrounding community (FAO, 2010). If not addressed with appropriate strategies, these issues could reduce pond productivity and hinder the development of a sustainable aquaculture sector. This finding is also consistent with research conducted by Akhmaddin et al. (2023), which found that the sustainability status of freshwater whiteleg shrimp *(Penaeus vannamei)* cultivation in Glagah District, Lamongan Regency, remains fairly sustainable, with an average index value of 55.69%. Based on the current management of whiteleg shrimp aquaculture in Lamongan Regency, an assessment of various related dimensions is required. Sustainability analysis uses the RAP-SF (Rapid Appraisal for Shrimp Farm) simulation, a modification

of RAPFISH. This study will utilize Multidimensional Scaling as a technique to assess multidisciplinary aspects influencing sustainability. Fauzi (2019) stated that RAPFISH is used to analyze the sustainability of the fisheries sector.

Multidimensional Scaling (MDS) is a multidisciplinary rapid method for determining the level of sustainability based on the number of attributes scored (Pitcher et al., 2001). Attributes within each dimension are evaluated to assess the sustainability of a program. This analysis is crucial for formulating development steps that are not only oriented toward increasing production and export competitiveness but also consider environmental sustainability and the well-being of coastal communities. Thus, this study was conducted to analyze the index and status of vannamei shrimp aquaculture sustainability based on ecological, economic, social, technological and institutional dimensions, the results of this study are very crucial to improve the sustainability of the management of vannnamei shimp pond in coastal areas, Lamongan Regency.

Method

Research Materials

The data required in the study consist of primary and secondary data. The primary data collection was conducted through observation methods, questionnaires, and interviews with research responden, while secondary data was obtained from references and related data, namely the Central Statistic Agency of Lamongan Regency, The Maritime Affairs and Fisheries Service of Lamongan Regency.

Research Design

The research was used a qualitative methode. The methode used to assess and analyze the feasibility of cultivating whiteleg shimp pond in coastal areas in Lamongan Regency based on sustainability index so that strategy can be developed for Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency. Based on Muchtar et al. (2023), the qualitative research method aims to analyze and describe phenomena or research objects through social activities, attitudes, and perceptions of people individually or in groups.

Work Procedure

The technique for determining the respondent sample used snowball sampling and purposive sampling. The sampling methode for a farmer respondents used in this study was a snowball sampling. The information of farmer respondents is based in the previoud respondent references. Purposive sampling is a sample determination based on certain considerations and adjusting the criteria in this study that respondents understand and related to the existing and internal condition on Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency.

Data Analysis

The data in this study were assessed for sustainability by analyzing several dimension of the sustainability of the Vaname Shrimp (*Penaeus vannamei*) Pond in Coastal Areas of Lamongan Regency. The analysis used for this study was the multidimensional scalling (MDS) method with the RAPFISH Application (Fauzi et al., 2002). The assessment (scoring) of each attribute is based on the sustainability criteria of each dimension that describes the condition of the level of sustainability of the research location (Airawati et al., 2023).

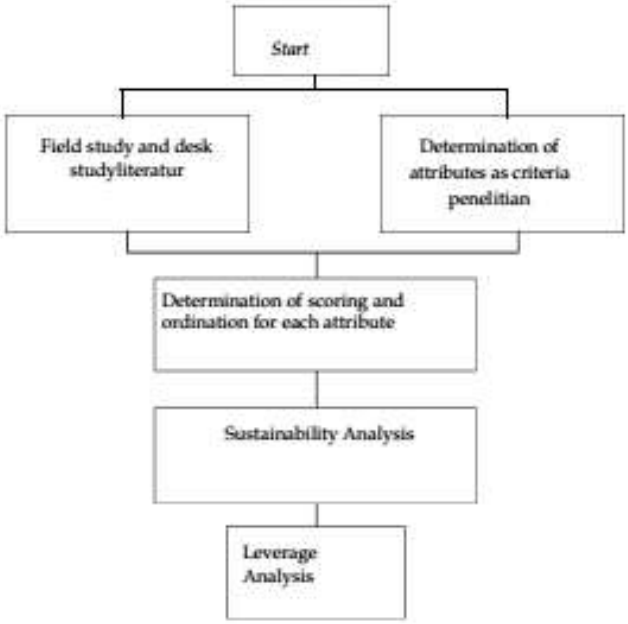

Figure 1. The stages of applying MDS (Fauzi & Anna, 2002)

Result and Discussion

Status of the Sustainability of Ecological Dimensions

Sustainability in this dimension focuses on the preservation of natural resources and the environment. The dimension as the center of ecological attention in stopping cultivation without capacity and quality of the ecosystem so as not to exceed the environmental carrying capacity (Fauzi et al., 2002). In the cultivation of whiteleg shrimp (*Penaeus vannamei*) in the coastal area of Lamongan Regency, this ecological dimension is calculated through 6 (six) attributes. These attributes consist of: (1) the use of environmentally friendly feed and drugs, (2) pollution levels, (3) environmental management, (4) air quality management, (5) pest attacks and (6) availability of electrical energy. The

assessment of these attributes was chosen to show the capacity of coastal areas to support pond cultivation permits. The result of the ordination test in multi-dimensional scalling (MDS) produced an output result, inn terms of overall ecological sustainability, pond 1 has a less sustainable status, with a sustainability index of 48.57, while pond 2 has a sustainability index of 55.50 and pond 3 has a sustainability index of 55.82, indicating a moderately sustainable status. This means that the pond ecology can still support short-term production, but long-term sustainability cannot be guaranteed. If not mitigated, this has the potential to reduce shrimp pond productivity, increase the risk of disease, and accelerate environmental degradation through eutrophication and organic sediment accumulation. Therefore, improvements in sensitive attributes are needed to determine the direction of good or bad sustainability (Achmad et al., 2020).

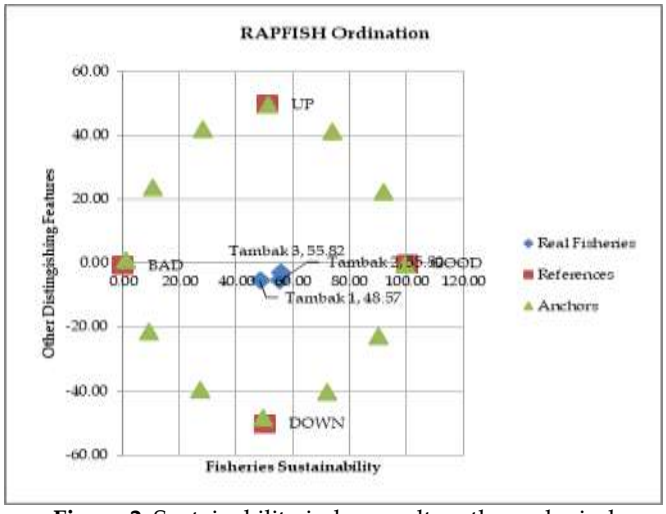

Figure 2. Sustainability index result on the ecological dimension in Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency

This is consistent with the sensitive attributes that influence the ecological index of this ecological dimension as seen from Leverage Analysis. The results of the leverage analysis in the figure above show that of the 6 attributes used in the ecological dimension assessment, there are 3 sensitive attributes that have an influence on the cultivation of whiteleg shrimp (*Penaeus vannamei*) in the coastal area of Lamongan Regency. In order, the attributes with the most sensitive influence are the level of pollution with a Root Mean Square (RMS) value of 3.00, pest attacks with a Root Mean Square (RMS) value of 2.4 and water quality management with a Root Mean Square (RMS) value of 2.3. The results of this study align with research conducted by Trihatmoko et al. (2016), which stated that shrimp farming activities cause spatial disharmony due to waste that directly pollutes the waters surrounding the ponds.

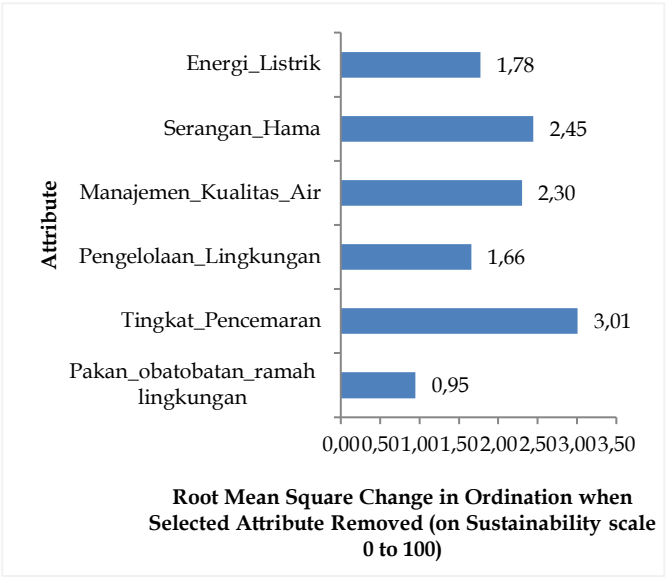

Figure 3. Result of the ecological dimension leverage analysis in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

Status of the Sustainability of Economic Dimensions

The sustainability status of vaname shrimp (*Penaeus vannamei*) cultivation in the economic dimension will be measured through 5 (five) attributes consisting of: (1) availability of employment, (2) impact on income, (3) availability of capital resources, (4) market availability and (5) maintenance prices. In this dimension, based on the results of Multidimensional Scaling Analysis, it shows that the overall status is quite good with a sustainability index of 60.83 in pond 1, while in pond 2 with a sustainability index value of 61.67. Pond 3 with a sustainability index value of 67.60 shows a fairly sustainable category and even approaches the good category according to the sustainability index. The index value which ranges between 60.83 – 67.70 indicates that the economic dimension of vaname shrimp cultivation in the coastal area of Lamongan Regency is at a moderate level of sustainability.

Sensitive attributes affecting the economic dimension's sustainability index are examined through Leverage Analysis. Mahida (2020) stated that the attribute with the highest sensitivity is indicated by the highest Root Mean Square (RMS) value. In the economic dimension, three attributes are identified as having the highest sensitivity values for the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation in the coastal areas of Lamongan Regency. These dimensions, in order, are: The capital resource attribute, the most sensitive and influential attribute affecting the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation in coastal areas of Lamongan Regency, indicates that cultivation activities still rely on self-funding. Semi-intensive whiteleg shrimp (*Penaeus vannamei*) cultivation techniques typically require

capital from financing institutions or banks. This is because whiteleg shrimp (*Penaeus vannamei*) cultivation in coastal areas of Lamongan Regency requires a significant amount of capital (Yanti et al. 2024). Capital is crucial for business sustainability and the sustainability of the coastal area/surrounding environment, based on its impacts (Desrizal, 2025).

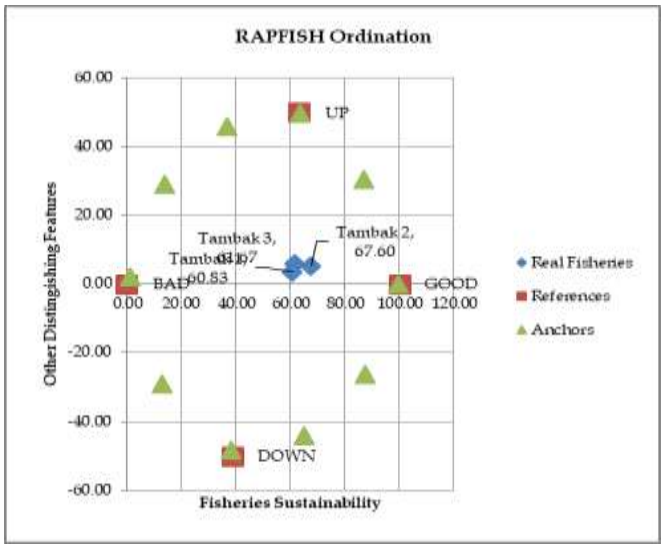

Figure 4. Sustainability index result on the economic dimension in Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency

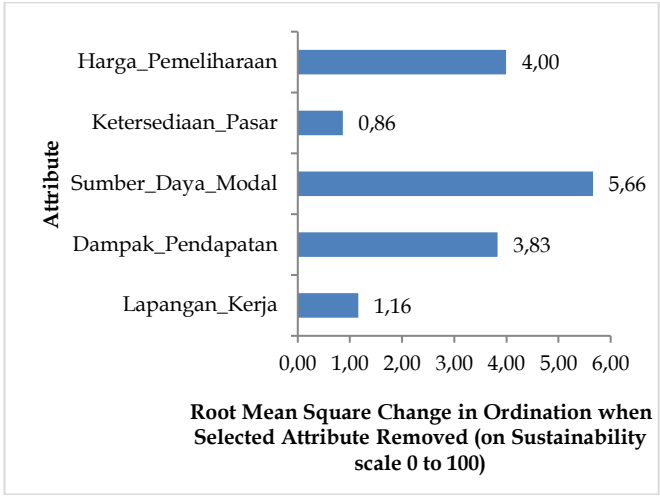

Figure 5. Result of the economic dimension leverage analysis in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

Therefore, financing institutions or banks, as sources of capital for shrimp cultivation, must ensure that proposed businesses are environmentally conscious by including a clause on environmental pollution prevention/environmental assessment in the capital application requirements (Wigiani, 2019). Farmers attempting to market their products face several challenges, including the lack of opportunity for farmers to determine prices due to a lack of direct access to cold storage during the sales process (Bumigora, 2022).

Status of the Sustainability of Social Dimensions

The sustainability status of vaname shrimp (*Penaeus vannamei*) cultivation in the social dimension will be measured through 6 (six) attributes consisting of: (1) training and socialization, (2) cultivation knowledge, (3) participation in sustainable management (4) interaction patterns (5) potential conflicts and (6) management compliance. In this dimension, based on the results of Multidimensional Scaling Analysis, it shows that the overall status is quite good with a sustainability index of 63.17 in pond 1, while in pond 2 with a sustainability index value of 66.79 and pond 3 with a sustainability index value of 55.58. In general, the three ponds have a sustainability index value of 55.58 - 66.79 which indicates that the social dimension of vaname shrimp ponds in the coastal area of Lamongan Regency is still not fully sustainable but is in a positive direction towards sustainability. So it has the potential to be strengthened especially in attributes with high sensitivity.

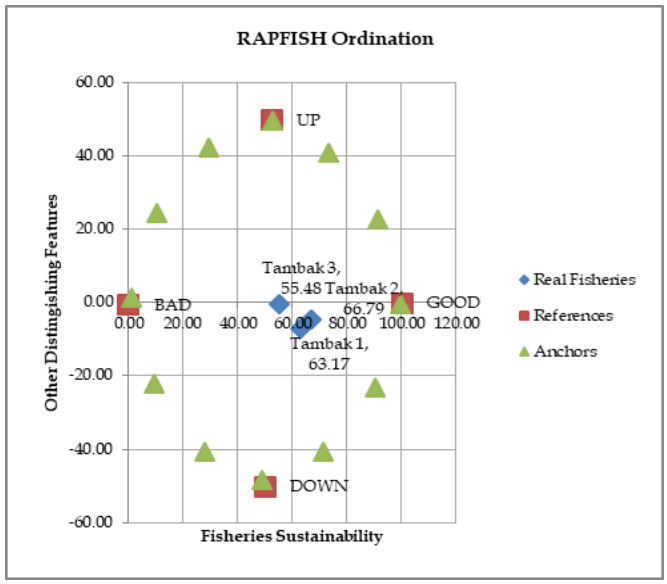

Figure 6. Sustainability index result on the social dimension in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

In the social dimension, it is known that there are 3 (three) attributes that have the highest sensitivity value on the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation in the coastal area of Lamongan Regency. In sequence, these dimensions consist of interaction patterns (RMS = 4.97), training and socialization (RMS = 2.97) and cultivation knowledge (RMS = 2.87). The coastal area of Lamongan Regency, which consists of communities with diverse ethnic and cultural backgrounds, creates interaction patterns in the

utilization of coastal areas to maintain the sustainability of community life. Based on research by Lestari (2017), it is stated that the interaction pattern in this activity is the existence of communication between landowners and land tenants and cultivators with buyers of cultivated products. Interaction patterns have the highest influence on social sustainability based on the results of this study.

Interaction patterns in sustainable aquaculture in whiteleg shrimp (*Penaeus vannamei*) ponds are aimed at dynamic and active relationship patterns between business actors, workers, surrounding communities, government and the environment (Susanti et al. 2021). This pattern will be the opening to form a productive pond system both economically, environmentally friendly and socially just for the surrounding community.

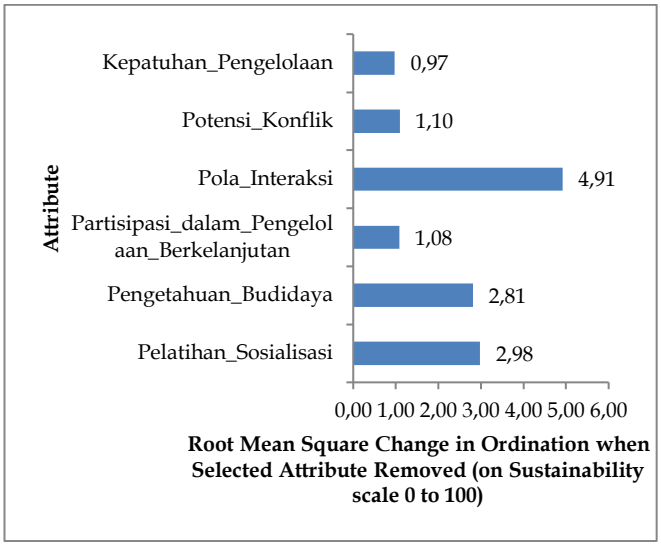

Figure 7. Result of the social dimension leverage analysis in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

Status of the sustainability of technological dimensions

According to Nasution et al. (2015), the use of technology is an absolute requirement in the construction and development of sustainable whiteleg shrimp (*Penaeus vannamei*) cultivation. The use of technology in cultivation can be seen from the intensity value of production input use in the cultivation. The sustainability status of whiteleg shrimp (*Penaeus vannamei*) cultivation in the technology dimension in this study was measured through 6 (six) attributes consisting of: (1) use of technology, (2) machine automation, (3) availability of facilities and infrastructure (4) use of IPAL technology (5) utilization of post-harvest technology and (6) RAS technology.

In this dimension, based on the results of Multidimensional Scaling Analysis, it shows that overall it has a fairly good status with a sustainability index of 57.57 in pond 1, while in pond 2 with a sustainability index value of 55.74 and pond 3 with a sustainability index value of 54.79. Based on the above values, the technology dimension which has an average value of 54.74 - 57.57 shows that the three ponds are included in the fairly sustainable category. This indicates that technology use at the three whiteleg shrimp ponds in Lamongan has been moderate, but there are still limitations in several areas, particularly in attributes with high sensitivity values. The position of the technology dimension point, which is between "bad" and "good," indicates that the cultivation technology is quite good but has not yet reached an optimal sustainable level. This is due to the limited application of wastewater treatment technology (WWTP) (Newton et al. 2021).

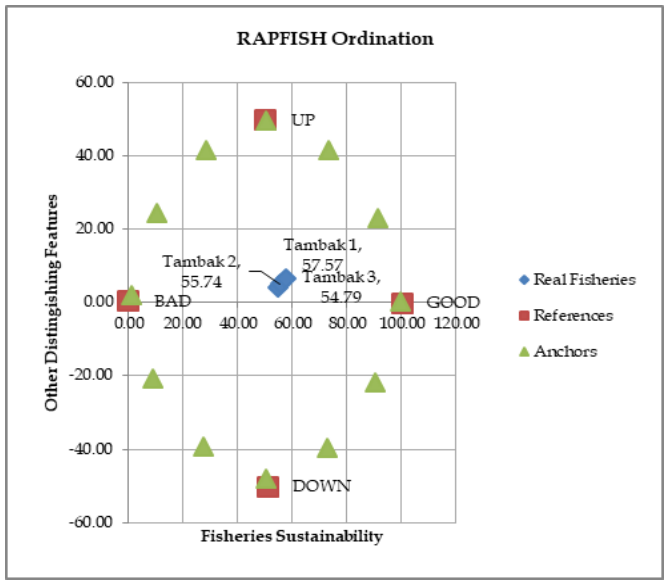

Figure 8. Sustainability index result on the technological dimension in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

In the technology dimension, three attributes were found to have the highest sensitivity values for the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation in coastal areas of Lamongan Regency. These dimensions, in order, are the use of wastewater treatment plant (WWTP) technology (RMS = 3.37), machine automation (RMS = 2.10), and the availability of facilities and infrastructure (RMS = 2.10). The technological dimension is a dimension that has quite an influence on the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation, starting with pond preparation through to harvesting, stocking the number and quality of fry and quality feed, to the use of chemical materials or drugs during the cultivation process, until the availability of wastewater treatment installations (WWTP) (Liufeto et al. 2019). The unavailability of wastewater treatment plants (WWTPs) will affect the

sustainability index value due to pollution in the area surrounding the pond cultivation (Fahmi, 2024).

Indicators of Success in the Development of Sustainable/Area-Based Whiteleg Shrimp (*Penaeus vannamei*) Cultivation are stated in the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 15 of 2022 concerning General Guidelines for the Development of Area-Based Whiteleg Shrimp (*Penaeus vannamei*) Cultivation, consisting of: (1) the construction of infrastructure at area-based whiteleg shrimp (*Penaeus vannamei*) cultivation locations, (2) increasing the productivity of area-based whiteleg shrimp (*Penaeus vannamei*) cultivation areas and the availability of pilot areas for whiteleg shrimp (*Penaeus vannamei*) cultivation that implement environmentally friendly, intensive technology.

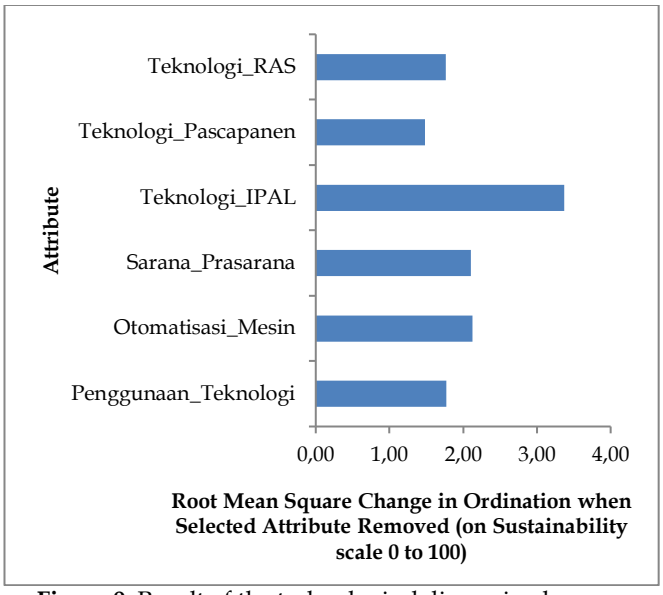

Figure 9. Result of the technological dimension leverage analysis in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

Status of the Sustainability of Institutional Dimensions

Institutional Dimension as one of the forums to accommodate and assist farmers in solving the problems faced will be measured its sustainability status in vaname shrimp (*Penaeus vannamei*) cultivation through 6 (six) attributes consisting of: (1) guidance with related agencies (2) cooperation with other parties, (3) monitoring and evaluation (4) availability of fishery farmer groups (5) coordination between stakeholders (6) effective and transparent management. In this dimension, based on the results of Multidimensional Scaling Analysis, it shows that the overall status is quite good with a sustainability index of 50.83 in pond 1, while in pond 2 with a sustainability index value of 53.02 and pond 3 with a sustainability index value of 57.90. Based on this analysis, the institutional dimensions of the three ponds are in the fairly sustainable category with an average value of 50.83 - 57.90. This shows that the institutional dimensions of vaname shrimp pond fisheries in the coastal area of Lamongan Regency have not run optimally but have a positive direction towards sustainability. In terms of ordinates, the three ponds are relatively close together, so this shows that the institutional structure, governance and coordination between actors are still in the development stage but still require strengthening coordination and evaluation between stakeholders (Ofori et al. 2022).

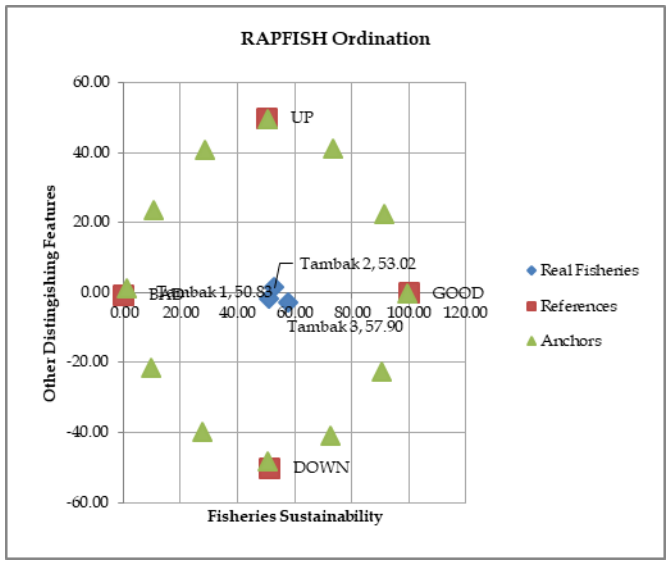

Figure 10. Sustainability index result on the institutional dimension in Vaname Shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency

In the institutional dimension, it is known that there is 1 (one) attribute that has the highest sensitivity value on the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation in the coastal area of Lamongan Regency, namely the monitoring and evaluation attribute with a Root Mean Square (RMS) value of 4.38. Monitoring and evaluation in this sustainability dimension are the attributes with the highest sensitivity with a value of 4.7. This indicates that this system is the weakest component and has a direct impact on institutional effectiveness and decision making. This institutional dimension plays an important role in creating the sustainability of whiteleg shrimp (*Penaeus vannamei*) cultivation, including related to the provision of assistance, technology transfer and the implementation of monitoring and evaluation (Akbarurrasyid et al., 2020).

Based on the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 15 of 2022 concerning General Guidelines for the Development of Area-Based Whiteleg Shrimp

(*Penaeus vannamei*) Cultivation, it states that monitoring and evaluation are part of the scope of the general guidelines. Monitoring and evaluation are carried out to ensure the successful implementation of activities in accordance with previously prepared plans (Paena et al. 2023). This activity was carried out on the cultivation location, the availability of cultivation facilities and infrastructure, the availability of whiteleg shrimp (*Penaeus vannamei*) rearing technology, shrimp and environmental health management, human resource management and institutional participation in efforts to implement Good Fish Cultivation Practices (CBIB) and Good Fish Rearing Practices (CPIB) (Nimrat et al. 2019). The results of this monitoring and evaluation can be used as considerations and recommendations in the implementation of policies related to sustainable whiteleg shrimp (*Penaeus vannamei*) cultivation in the coastal areas of Lamongan Regency in stages by the Local Government to the Central Government.

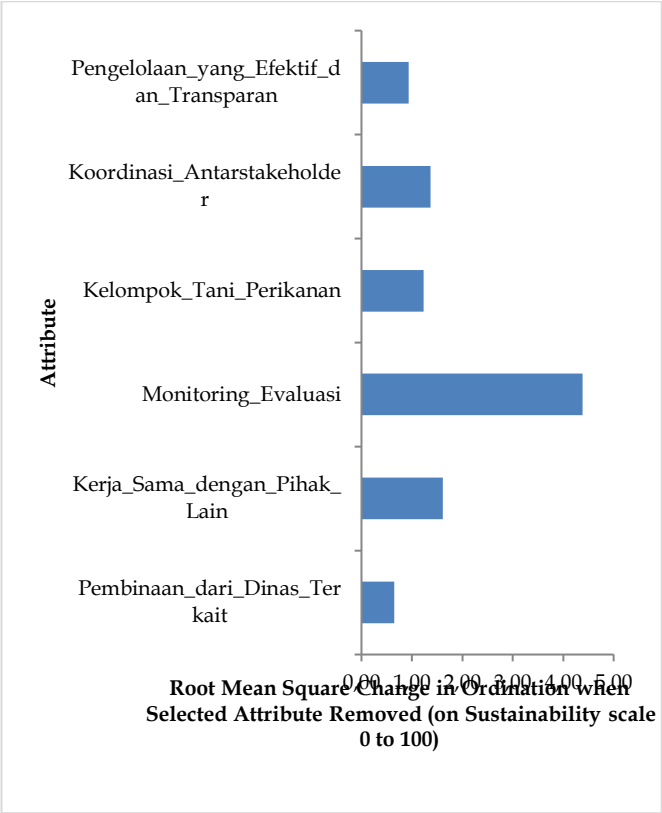

Figure 11. Result of the institutional dimension leverage analysis in Vaname Shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

Multidimensional Sustainability Status

Based on multidimensional scalling analysis, an ordinating test was conducted on each dimension of sustainability, namely the ecological, economic, social, technological dan institutional dimension. The results of the ordination test in this study obtained statistical value in the form of stress values and determination coeficients (R^2) from each dimension (Table 2). The stress value was obtained in the ecological dimensions which was 19,3%, the economic dimensions which was 19,4%, the social dimensions which was 18,9%, the technological dimensions 19,5% and the institutional dimensions which was 19.0%.

The determination coefficient value obtained in this test was the ecological, economic, and social dimensions which was 92.6%, technological dimension which was 92.2%, the institutional dimensions obtained values 92.7%. Based on the result of the ordination test, the stress value in multi-dimensional (MDS) analysis was less than 25% and the determination coefficient was more than 90% indicating perfect analysis accuracy condition. The stress value describes the accuracy of the configuration in the MDS analysis of the original data.

Table 1. The Result of Statistical Values in the MDS Ordination Analysis on the Sustainability of Vaname Shimp Aquaculture in Coastal Area, Lamongan Regency

Dimension	Stress		R^2	
	Statistic Value	%	Statistic Value	%age
Ecological	0.193	19.3	0.926	92.6
Economic	0.194	19.4	0.926	92.6
Social	0.189	18.9	0.926	92.6
Technological	0.195	19.5	0.922	92.2
Institutional	0.190	19.0	0.927	92.7

The analysis in this study on Vannamei Shrimp Pond in Coastal Area, Lamongan Regency produces a sustainability index value. At the end of this study, the result of the RAPFISH analysis by analyzing each dimensions of sustainability so that overall it can be seen that the vaname shrimp pond in Coastal Area, Lamongan Regency shown the status with value range 50-75 is included in the quite sustainable category. The result of the analysis are interpreted through a flyover diagram to be able to describe tha sustainability condition of the vaname shrimp pond in coastal area, Lamongan Regency.

The result of the sustainability analysis in the flyover diagram illustrate the relative position of the sustainability index value based on each dimensions of sustainability. In the flyover diagram, it can be seen that sustainability based on the economic and social aspect has the highest value compared to other dimensions, as indicated by the lines of the larger planes that lead to the outer corner (sustainability angle). This indicates that the whiteleg shrimp ponds in the coastal areas of Lamongan Regency are quite competitive due to their open access to local and export markets and their strategic location, as well as operational cost efficiency. It also demonstrates that social dimensions such as community participation, welfare, and social relations among farmers are functioning well. This is supported

by high levels of local labor participation and absorption, thereby reducing poverty in Lamongan Regency, especially in coastal areas. This situation must be maintained and strengthened to maintain interest in whiteleg shrimp farming in the region.

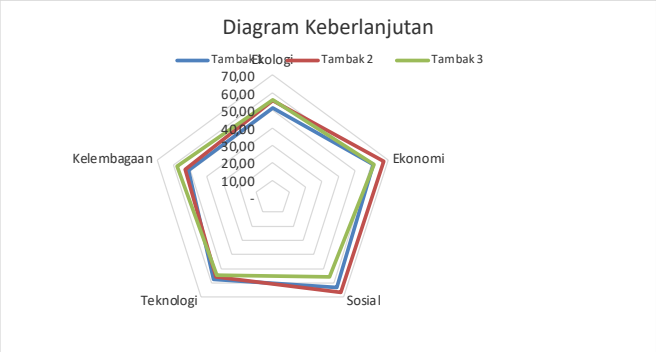

Figure 12. Flyover diagram of the sustainability status of vaname shrimp *(Penaeus vannamei)* pond in coastal areas of Lamongan Regency

The result of the analysis that has been carried out can produce recommendations for improvement plans as an effort for management strategies and improving vaname pond in coastal area, Lamongan Regency. Determination of recommendations is based on leverage analysis, so that sensitive attributes index value and maintain business pond conditions in the quite sustainability. Increasing the capacity and independence of coastal communities is recommended to maintain the economic and social sustainability of surrounding communities, especially in coastal areas. This can be implemented through training in entrepreneurship based on pond products, such as processing shrimp derivatives, liquid fertilizer from pond waste, or alternative feed. Market access also needs to be expanded through collaboration with fisheries cooperatives, microfinance institutions, and e-commerce platforms to increase competitiveness and supply chain efficiency. Furthermore, strengthening social institutions in the form of farmer groups or pond cooperatives is expected to strengthen the bargaining position of farmers, increase community participation, and expand local employment in coastal areas of Lamongan Regency.

Sustainability can be improved through the adoption of environmentally friendly technologies and the digitalization of pond monitoring systems. Local governments, along with academics and the private sector, need to promote the use of Internet of Things (IoT) technology for real-time monitoring of water quality parameters such as temperature, pH, dissolved oxygen, and salinity. Furthermore, the implementation of biofloc and Recirculating Aquaculture Systems (RAS) is recommended as a measure to improve water efficiency and manage aquaculture waste. The development of polyculture systems (shrimp-milkfish, shrimp-seaweed, or shrimp-crab) also needs further testing to increase productivity and stability of pond ecosystems. To support institutional sustainability, the Lamongan Regency Fisheries Service needs to improve its coaching, monitoring, and evaluation functions for aquaculture activities. The government needs to strengthen synergy between stakeholders (local government, universities, the private sector, and community groups) by establishing the Lamongan Sustainable Aquaculture Forum as a forum for coordination, collaboration, and technology transfer. Furthermore, environmental incentive policies, such as the provision of "Green Pond" certifications or subsidies for farmers implementing environmentally friendly aquaculture systems, can encourage the implementation of sustainability principles at the business level.

Conclusion

The conclusion value of the sustainability index based on the ecological, economic, social, technological and institutional dimensions in the vaname shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency shown the status with value range 50-75 is included in the quite sustainable category. Efforts to increase the sustainability index and maintain the sustainability of the vaname shrimp *(Penaeus vannamei)* Pond in Coastal Areas of Lamongan Regency, so that it can run optimally through a management strategy. Increasing the capacity and independence of coastal communities is recommended to maintain the economic and social sustainability of surrounding communities, especially in coastal areas. This can be implemented through training in entrepreneurship based on pond products, such as processing shrimp derivatives, liquid fertilizer from pond waste, or alternative feed. Sustainability can be improved through the adoption of environmentally friendly technologies and the digitalization of pond monitoring systems. Local governments, along with academics and the private sector, need to promote the use of Internet of Things (IoT) technology for real-time monitoring of water quality parameters such as temperature, pH, dissolved oxygen, salinity and implementation of biofloc and Recirculating Aquaculture Systems (RAS). To support institutional sustainability, the Lamongan Regency Fisheries Service needs to improve its coaching, monitoring, and evaluation functions for aquaculture activities.

Acknowledgments

Acknowledgments contain all parties/personnel other than the authors who significantly support the research. If the

research was funded by a certain grant, the grant provider along with the grant number must also be mentioned.

Author Contributions
Conceptualization: DEK, AMSH and JB; data collection: DEK; data analysis, methodology, validation and data curration: DEK and AMSH; writing, original draft, review and edit: DEK, AMSH and JB.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare that there is no conflict of interest among all authors upon writing and publishing the manuscript.

References

Achmad, A., Susiloningtyas, D., & Handayani, T. (2020). Sustainable aquaculture management of vannamei shrimp (*Penaeus vannamei*) in Batukaras Village, Pangandaran, Indonesia. *International Journal of Geomate, 19*(72), 151–158. https://doi.org/10.21660/2020.72.5727

Ahmed, N., Thompson, S., & Glaser, M. (2017). Integrated mangrove-shrimp cultivation: Potential for blue carbon sequestration. *Ambio*. https://doi.org/10.1007/s13280-017-0946-2

Airawati, M., Fauzi, I., Mardiatno, D., & Khakhim, N. (2023). Analisis kebijakan keberlanjutan budidaya udang vaname di Kabupaten Purworejo, Jawa Tengah. *Jurnal Kebijakan Sosial Ekonomi Kelautan dan Perikanan, 13*, 155. https://doi.org/10.15578/jksekp.v13i2.12487

Akbarurrasyid, M., Tarigan, R. R., & Atiek, D. (2020). Analysis of shrimp *Penaeus vannamei* farming business sustainability in the Cempi Bay, Dompu West Nusa Tenggara. *Indonesian Journal of Fisheries Science and Technology, 16*(4), 250. Retrieved from http://ejournal.undip.ac.id/index.php/saintek

Akhmaddin, D. B., & Mahmudi, M. (2023). Sustainability status of freshwater white shrimp (*Penaeus vannamei*) culture in Glagah District, Lamongan Regency, East Java. *Economic and Social of Fisheries and Marine Journal, 11*(1), 1–14. Retrieved from https://doi.org/10.21776/ub.ecsofim.2023.011.01.01

Badan Pusat Statistik Kabupaten Lamongan. (2022). *Jumlah penduduk menurut kabupaten/kota di Provinsi Jawa Timur (ribu), 2017–2021.* Retrieved from https://lamongankab.bps.go.id/id/statistics-table/1/NTM0OCMx/jumlah-penduduk-menurut-kabupaten-kota-di-provinsi-jawa-timur-ribu-2017-2021.html

Badan Pusat Statistik Kabupaten Lamongan. (2023). *Produksi dan nilai produksi perikanan budidaya tambak sederhana dan tambak semi intensif menurut kabupaten/kota dan jenis budidaya di Provinsi Jawa Timur, 2021.* Retrieved from https://jatim.bps.go.id/id/statistics-table/1/MjYyMyMx/produksi-dan-nilai-produksi-perikanan-budidaya-tambak-sederhana-dan-tambak-semi-intensif-menurut-kabupaten-kota-dan-jenis-budidaya-di-provinsi-jawa-timur--2021.html

BPS Kabupaten Lamongan. (2024). *Kecamatan Paciran dalam angka 2024.* Retrieved from https://lamongankab.bps.go.id/id/publication/2024/09/26/b8530d251861ac9592653e24/kecamatan-paciran-dalam-angka-2024.html

Brundtland, G. H. (2017). Our common future ("The Brundtland Report"): World Commission on Environment and Development. In *The top 50 sustainability books* (pp. 52–55). https://doi.org/10.4324/9781351279086-15

Chen, S., Wang, J., Che, B., & Sun, C. (2023). Ecological footprint of different culture modes of *Penaeus vannamei* in northern China. *Water, 15*(16), 2981. https://doi.org/10.3390/w15162981

Desrizal, D. (2025). Legal status of aquaculture ponds and coastal compliance in Padang Pariaman. *IOP Conference Series: Earth and Environmental Science, 1543*(1), 012018. https://doi.org/10.1088/1755-1315/1543/1/012018

Fahmi, R. M. A. N. A. W. A. H. (2024). Manajemen kualitas air budidaya udang vaname (*Penaeus vannamei*) di IBL Prigi, Kabupaten Trenggalek. *Jurnal Sains dan Teknologi, 3*, 37–46. https://doi.org/10.58169/saintek.v3i2.651

Farabi, A. I., & Latuconsina, H. (2023). Manajemen kualitas air pada pembesaran udang vaname (*Penaeus 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.v5i1.2097

Fauzi, A., & Anna, S. (2002). Evaluasi keberlanjutan pembangunan perikanan: Aplikasi Rapfish (studi kasus perairan pesisir DKI Jakarta). *Jurnal Pesisir dan Lautan, 4*(3), 43–55. Retrieved from https://www.crc.uri.edu/download/

Imam. (2023). *Strategi melesatkan udang ke Eropa dan Tiongkok.* Portal Informasi Indonesia.

Isman, H., Rupiwardani, I., & Sari, D. (2022). Gambaran pencemaran limbah cair industri tambak udang terhadap kualitas air laut di pesisir Pantai Lombeng. *Jurnal Pendidikan dan Konseling, 4*(3), 1349–1358. https://doi.org/10.31004/jpdk.v4i5.7169

Kementerian Kelautan dan Perikanan Republik Indonesia. (2021). *Statistik kelautan dan perikanan Provinsi Jawa Timur.* Retrieved from

https://dkp.jatimprov.go.id/public/uploads/2023/08/rb_lampiran_20230807044745_919860.pdf

Krummenauer, D., Peixoto, S., Cavalli, R., Poersch, L., & Wasielesky, W. (2011). Superintensive culture of white shrimp, *Penaeus vannamei*, in a biofloc technology system in southern Brazil at different stocking densities. *Journal of the World Aquaculture Society, 42*(5), 726–733. https://doi.org/10.1111/j.1749-7345.2011.00507.x

Latuconsina, H. (2016). *Perairan: Ekologi perairan tropis – Prinsip dasar pengelolaan sumber daya hayati*. Gadjah Mada University Press.

Liufeto, F., Soemarno, S., Ekawati, A., & Harahab, N. (2019). A study of carrying capacity of water resources for the development of eco-friendly shrimp farming in Malaka Regency, West Timor of Indonesia. *Russian Journal of Agricultural and Socio-Economic Sciences, 90*(6), 178–191. https://doi.org/10.18551/rjoas.2019-06.24

Muchtar, Hermana, D., Hanifah, H. S., & Anggraeni, W. A. (2023). Peran media komunikasi pemerintahan dan perilaku birokrasi dalam pelayanan publik (studi pada Kecamatan Tarogong Kaler Garut). *Professional: Jurnal Komunikasi dan Administrasi Publik, 10*(1), 179–188. https://doi.org/10.37676/professional.v10i1.3932

Newton, R., Zhang, W., Xian, Z., McAdam, B., & Little, D. (2021). Intensification, regulation and diversification: The changing face of inland aquaculture in China. *Ambio, 50*(9), 1739–1756. https://doi.org/10.1007/s13280-021-01503-3

Nimrat, S., Khaopong, W., Sangsong, J., Boonthai, T., & Vuthiphandchai, V. (2019). Improvement of growth performance, water quality, and disease resistance against *Vibrio harveyi* of postlarval whiteleg shrimp (*Penaeus vannamei*) by administration of mixed microencapsulated *Bacillus* probiotics. *Aquaculture Nutrition, 26*(5), 1407–1418. https://doi.org/10.1111/anu.13028

Nurdiansyah, M. A., & Rosmiati, M. (2020). Sustainability analysis and management strategy for white shrimp aquaculture. *Sosioteknologi, 19*(4), 441. https://doi.org/10.5614/sostek.itbj.2020.19.3.10.

Ofori, S., Kodikara, S., Jayatissa, L., Madarasinghe, S., Nijamdeen, T., & Dahdouh-Guebas, F. (2022). What is the ecological footprint of aquaculture after five decades of competition between mangrove conservation and shrimp farm development? *Aquatic Conservation: Marine and Freshwater Ecosystems, 33*(1), 15–28. https://doi.org/10.1002/aqc.3897

Oliveira, C. T. A., Barreto, M. K., & Henry-Silva, G. G. (2025). Assessing the environmental, economic and social sustainability of marine shrimp (*Penaeus vannamei*) cultures at different stocking densities in a semi-arid tropical region. *Aquaculture, 598*. https://doi.org/10.1016/j.aquaculture.2024.741986

Paena, M., Mustafa, A., Tarunamulia, T., Asaf, R., Athirah, A., Kamariah, K., & Taukhid, I. (2023). Analysis of water quality status and water carrying capacity for the development of intensive technology vaname shrimp ponds in Bulukumba District, South Sulawesi Province, Indonesia. *BIO Web of Conferences, 74*, 01009. https://doi.org/10.1051/bioconf/20237401009

Pereira, S. A., Kimpara, J. M., & Valenti, W. C. (2021). Sustainability of the seaweed *Hypnea pseudomusciformis* farming in the tropical Southwestern Atlantic. *Ecological Indicators, 121*, 107101. https://doi.org/10.1016/j.ecolind.2020.107101

Kementerian Kelautan dan Perikanan Republik Indonesia. (2023). *5 program prioritas berbasis ekonomi biru di tahun 2024.* Retrieved from https://kkp.go.id/

Kementerian Kelautan dan Perikanan Republik Indonesia. (2024). *Laporan kinerja Kementerian Kelautan dan Perikanan tahun 2023.* Retrieved from https://kkp.go.id/download-pdf-akuntabilitas-kinerja/akuntabilitas-kinerja-pelaporan-kinerja-laporan-kinerja-kkp-2023.pdf

Pemerintah Republik Indonesia. (2021). *Peraturan Pemerintah Nomor 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup.* Sekretariat Negara Republik Indonesia. Retrieved from http://www.jdih.setjen.kemendagri.go.id/

Susanti, L., Utomo, S., & Takarina, N. (2021). Sustainability and feasibility assessments of nanobubble aeration technology in economic-socio environment of *Penaeus vannamei* shrimp farming. *BIO Web of Conferences, 33*, 05005. https://doi.org/10.1051/bioconf/20213305005

Wigiani, D. P. (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

Yanti, S., Zulkarnaini, Z., & Yanti, C. (2024). Status of sustainability of vaname shrimp (*Penaeus vannamei*) in Kayu Ara Permai Village, Sungai Apit Subdistrict, Siak Regency. *International Journal of Social Science and Human Research, 7*(8). https://doi.org/10.47191/ijsshr/v7-i08-67

Zhou, J., Fang, W., Yang, X., Zhou, S., Hu, L., Li, X., & Xie, L. (2012). A nonluminescent and highly virulent *Vibrio harveyi* strain is associated with "bacterial white tail disease" of *Penaeus vannamei*

shrimp. *PLoS One, 7*(2), e29961. https://doi.org/10.1371/journal.pone.0029961