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SUSTAINABILITY OF VANAME SHRIMP (*Litopenaeus vannamei*) FARMING IN BANTAN DISTRICT BENGKALIS REGENCY RIAU

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ABSTRACT

Bantan district is one of the districts on the coast of Bengkalis Regency, which has great potential to contribute to vaname shrimp production through intensive technology pond-based farming activities. This study aims to assess the sustainability status of vaname shrimp farming in the Bantan District. The data processing and data analysis were performed using Multi-Dimensional Scaling (MDS); the ordination process is performed using the ordination technique called Rapid Appraisal for Shrimp Farm (Rap-SF), which is a modification of Rap-FISH Rapid Appraisal for fisheries (Rapfish) using five dimensions namely ecological, economic, social, institutional, and technological. The research results show the sustainability index of the ecological dimension with a value of 47.27 (less sustainable), the economic dimension with a value of 59.55 (quite sustainable), the social dimension 52.88 (quite sustainable), the institutional dimension 47.10 (less sustainable) and the technological dimension 63.35 (quite sustainable). Technological and economic dimensions have a considerable influence on the sustainability of vaname shrimp farming in the Bantan District.

Keywords: Vaname Shrimp, Sustainability, Rap-SF

1. INTRODUCTION

Shrimp is one of the fisheries' sub-sector products, and it is an export commodity with high economic value. Shrimp is also one of the marine and aquaculture products that is most consumed by the Indonesian people[1]. Whiteleg shrimp (*Litopenaeus vannamei*) is one of the types of shrimp that can be cultivated in Indonesia. Whiteleg shrimp entered Indonesia in 2001, and in May 2002, the government permitted two private companies to import 2,000 whiteleg shrimp broodstock. In addition, it also imported 5 million fries from Hawaii and Taiwan and 300,000 from Latin America. A beginner hatchery then bred the broodstock and fry[2].

Bengkalis Regency is one of the regencies that is developing vaname shrimp farming business activities. The development of vaname shrimp farming activities in Bengkalis Regency is supported by its territory, which is influenced by two different oceanographic characteristics. Several areas in Bengkalis Regency are directly adjacent to the sea, including the district capital, which is located on Bengkalis Island. This condition has a good impact on the region because it has the potential for developing fishery and cultivation commodities. The main potential that is managed is shrimp farming[3].

The vaname shrimp farming business in Bengkalis Regency is spread across several areas, one of which is in Bantan District. According to the Bengkalis Regency Marine and Fisheries Service 2024, the number of vaname shrimp farming business actors in the Bantan District is 36 business actors[4]. Bantan District is a strategic area for the development of vaname shrimp cultivation because it is an estuary located on Bengkalis Island. The condition of the waters in the coastal environment of Bengkalis Island, which is directly connected to the open sea in the Malacca

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Strait, is greatly influenced by the effects of tides, and the mass of water is a mixture of seawater and fresh water. This condition makes the salinity of the waters good for cultivation activities[5].

The vaname shrimp farming business with intensive technology in the Bantan District is currently a very productive economic activity in terms of developing the economic welfare of the Bengkalis community. However, the validity of its sustainability is determined by the available carrying capacity and its impact on the surrounding environment. The management of the vaname shrimp business, with the current intensive technology and future development efforts, requires an assessment of the availability of carrying capacity and the impacts caused to the environment so as to be able to provide an overview of its sustainability[6].

Sustainability means "to hold up," which can be interpreted as "able to continue continuously[7]. Sustainable development is a development process that ensures that current human needs are met while maintaining the availability of resources for the benefit of future generations[8]. Aquaculture development must be seen from various aspects because activities that only prioritize one aspect and ignore other aspects can damage the ecosystem and ultimately threaten the sustainability of resources. Five aspects of sustainability must be considered: 1) ecological sustainability (maintaining stock/biomass and increasing the capacity and quality of the ecosystem), 2) economic sustainability (the welfare of farmers and related parties at the individual level), 3) social sustainability (community welfare), 4) institutional sustainability (sustainable and efficient administration) and 5) technological sustainability (adequate infrastructure and technology)[9].

Referring to the concept of sustainable cultivation development, in order to utilize cultivation resources to meet current and future needs, sustainable cultivation must meet the requirements, including not damaging the environment, being profitable, and being accepted by the community. Assessing the condition of the coastal area of the Bantan District that vaname shrimp cultivation activities have utilized, it is necessary to measure the sustainability factors by integrating various dimensions, including ecological, social, economic, legal, and institutional aspects, as well as technology, in order to obtain a comprehensive picture of the sustainability status of the coastal area.

2. RESEARCH METHOD

Time and Place

This research was conducted in June 2024 in Bantan District, Bengkalis Regency, Riau Province, considering that Bantan District is one of the brackish water aquaculture centers on Bengkalis Island, which develops vaname shrimp farming business activities.

Method

The method used in this study is a survey method with a quantitative approach. The quantitative method is a research method based on the philosophy of positivism, used to research certain populations and samples, data collection using research instruments, and quantitative/statistical data analysis aimed at testing established hypotheses[10].

Procedures

Respondent Determination

The respondents were selected using a purposive sampling technique. The researcher's criteria for selecting respondents to obtain information come from government elements, such as fisheries service staff in the field of cultivation, fisheries extension workers in Bantan District, 36 vaname shrimp farmers in Bantan District, and a prominent community leader. Therefore, the total number of respondents selected in this study was 39.

Data Collection

The data collection techniques used in this study include observation, interviews

guided by structured questionnaires, and literature reviews. The data collected comprised both primary and secondary data in the study. Primary data was obtained from structured interviews with farmers using a questionnaire. Secondary data were obtained from related agencies such as the Marine and Fisheries Service and the results of previous related studies.

Data analysis

The data processing and analysis method is carried out using the Multi-Dimensional Scaling-Rapid Appraisal for Sustainability (MDS) Method. The ordination process is performed using the ordination technique, which in this study is called Rapid Appraisal for Shrimp Farm (Rap-SF). Rap-SF is a modification of Rap-FISH using five dimensions: ecology, economy, social, institutional, and technology. In Rap-FS, sustainability is described quantitatively by a set of criteria defined in numerical analysis by a set of attributes that are scored[11].

The stages of MDS (Multi-Dimensional Scaling) analysis involve several steps, beginning with attribute determination. 30 attributes were identified and distributed across five dimensions for analysis: 6 attributes for the ecological dimension, 6 for the economic dimension, 6 for the social dimension, 6 for the institutional dimension, and 6 for the technological dimension. (2) assessment of each attribute on an ordinal scale (scoring) based on sustainability criteria in each dimension; (3) Rapfish ordination analysis using the MDS method to determine ordination and stress values; (4) assessment of the index and sustainability status of pond businesses both in each dimension and multidimensionally by referring to sustainability criteria based on (5) sensitivity analysis to determine sensitive attributes that influence sustainability. There are three rules to determine the sustainability level attributes such as a) the law of bars or extreme values, b) the law of the middle value (RMS value above the average value or middle value), and c) the Pareto optimum law. The method to determine the sensitive attributes of the sustainability of the vaname shrimp farming business in the Bantan District uses a 75% Pareto optimum analysis by accumulating attributes with the highest RMS value, (6) Monte Carlo analysis to determine the stability of the ordination results[12-14].

Table 1. Guidelines for sustainability assessment of vaname shrimp

Index value	category
< 25.00	Bad (not sustainable)
25.00 – 49.99	Less (less sustainable)
50.00 – 74.99	Good (quite sustainable)
> 75.00	Very Good (continuous)

3. RESULT AND DISCUSSION

Sustainability of Vaname Shrimp Farming Business in Bantan District

The sustainability of the vaname shrimp farming business in the Bantan District was analyzed using the Multi-Dimensional Scalling method using Rapfish (Rapid Appraisal Technique for Fisheries), which is used to estimate the level of sustainability in vaname shrimp farming business from various dimensions. Rapfish produces index values and sustainability statuses for each dimension, as well as multidimensional vaname shrimp farming businesses in the Bantan District. Determination of the sustainability status of the vaname shrimp farming business uses five dimensions, namely ecology, economy, social, institutional, and technology, with a total of 30 attributes consisting of 6 attributes severally in each dimension. To obtain the sustainability index, each dimension of each attribute is arranged and filled with the current existing data conditions, then analyzed using MDS[14].

Ecological Dimension

The sustainability of the ecological dimension will provide an overview of the extent to which ecological capabilities support the activities of vaname shrimp farming. The support of ecological

conditions in the process of vaname shrimp farming activities will provide a positive assessment of the sustainability of the farming business. Conversely, if the ecological conditions are unable to provide support for the farming process, it will provide a bad value for the sustainability of the farming business, and this negatively impacts conducted sustainably. The ecological dimension attribute is focused on the attribute that is considered to influence the level of sustainability of the ecological dimension of vaname shrimp cultivation.

The results of the Rapfish analysis on the ecological dimension show a sustainability index value of 47.27, and this value is categorized as less sustainable (25.00-49.99), as seen in Figure 1. These results show that the ecological dimension is one aspect that requires improvement in its management by the government/ stakeholders in an effort to improve or even increase the sustainability status of shrimp farming businesses in Bantan District.

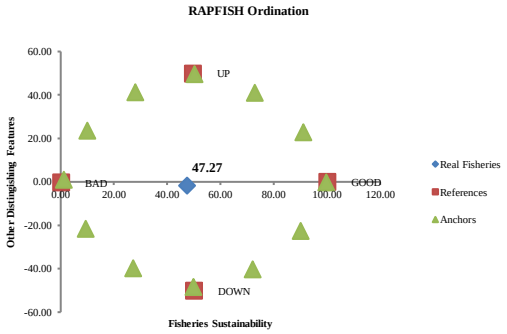

Figure 1. Status of sustainability of ecological dimension

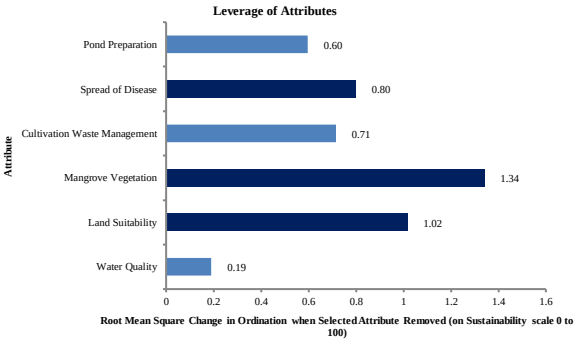

Figure 2. Attribute sensitivity in the ecological dimension

A sensitivity analysis is needed to identify the attributes that influence the sustainability of the ecological dimension. The results of the sensitivity analysis obtained the Root Mean Square (RMS) value of each ecological dimension attribute. The RMS value indicates the level of influence of the attribute on the sustainability index value. The largest RMS value indicates the attribute with the greatest influence, and vice versa; the attribute with the smallest RMS value also has a small influence on the sustainability index value[11].

Figure 2 shows the RMS value of each attribute that influences the sustainability of the ecology. To determine the attributes sensitive to sustainability using Pareto analysis, sort the magnitude of the RMS value of the sensitivity analysis results from the largest value to the smallest value, then weigh them in the form of a percentage after that is accumulated. Furthermore, the attributes are taken until the maximum cumulative value reaches 75%[11]. Based on the Pareto analysis, three sensitive attributes were obtained that influenced the ecological dimension sustainability index value, namely the mangrove vegetation attribute, the land availability attribute, and the disease spread attribute.

Implementing policies that can improve and increase sustainability in the ecological dimension involves supervising the management of shrimp farming land in accordance with regulations and providing assistance to farmers in determining quality seeds to reduce and prevent shrimp that are susceptible to disease.

Economic Dimension

The economic dimension is one of the most important aspects of sustainable development. Effectiveness in the economic dimension will have a good effect on the welfare of the community in the cultivation area. In addition, with increasing economic welfare, the possibility of creating sustainable development will be greater15.

The existence of economic dimensions in the vaname shrimp farming business in Bantan District provides an assessment of the extent to which the economic aspect supports the existence of the name shrimp farming business in Bantan District. The economic aspect of the vaname shrimp farming business in the Bantan District is assessed by the ability of economic development created by the existence of the vaname shrimp farming business. The economic support created by the existence of the vaname shrimp farming business provides an overview of the success of vaname shrimp farming in the Bantan District.

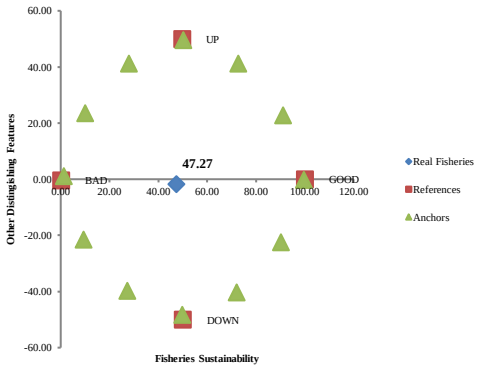

Figure 3. Status of sustainability of economic dimension

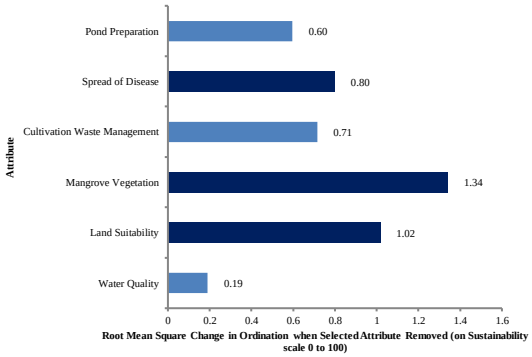

Figure 4. Attribute sensitivity in the economic dimension

This value is classified as fairly sustainable (50.00-74.99), indicating that the vaname shrimp farming business in Bantan District demonstrates a positive economic performance. The vaname shrimp farming business provides economic support that is economically beneficial to farmers in Bantan District. The economic sustainability status of the shrimp farming business is classified as a fairly sustainable category, meaning that shrimp farming provides economic benefits for farmers[16].

Figure 4 shows the RMS value of each attribute. A sensitivity analysis was conducted to discover which attribute has the greatest influence on the sustainability of the economic dimension. Attributes that are sensitive to the sustainability of the economic dimension based on the 75% optimum Pareto analysis include the shrimp selling price attribute, the wage amount attribute, and the product marketing attribute.

Management improvements that can be made to the attribute of the selling price of white leg shrimp are to assist in the form of counseling to white leg shrimp farmers to maintain the quality of white leg shrimp production so that the selling price of white leg shrimp gets a high price. The management strategy for assessing wages is to conduct job training to enhance the skills and expertise of whiteleg shrimp farmers. This enhancement of abilities should, in turn, encourage higher wages that reflect the advanced skills possessed by the farmers[17].

Social Dimension

Social or cultural activities formed due to the existence of vaname shrimp farming in Bantan District provide an overview of the sustainability of vaname shrimp farming in Bantan District. The results of the Rap-SF analysis on the social dimension show a sustainability index value of 52.88 (Figure 5). This value is classified as fairly sustainable (50.00-74.99). The sustainability index value of more than 51.00 suggests that the ecological conditions of the area are sufficient to support cultivation management. However, this value is close to the threshold of the less sustainable category, indicating there is a vulnerability. This condition is highly susceptible to degradation if proper management attention

is not given, potentially impacting sustainability across other dimensions[18].

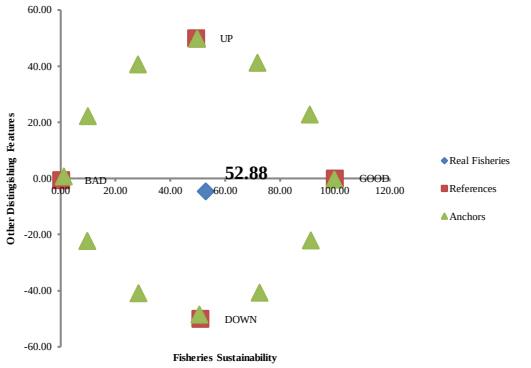

Figure 5. Status of sustainability of social dimension

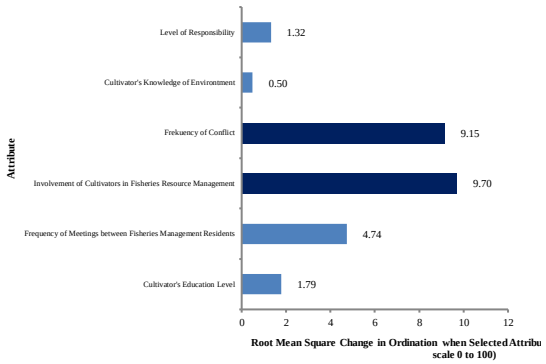

Figure 6. Attribute sensitivity in the social dimension

To find out which attributes influence the sustainability index value, a sensitivity analysis (leverage analysis) is needed. The results of the sensitivity analysis (leverage analysis) obtained the RMS value of each economic dimension attribute. Figure 6 presents the RMS value of each attribute that affects the sustainability of the social dimension of the vaname shrimp farming business in the Bantan District. According to the Pareto analysis, sensitive attributes are obtained for the sustainability of the social dimension of the sustainability of the vaname shrimp pond business in Bantan District, including the attribute of farmer involvement in fisheries resource management and the attribute of conflict frequency.

Policies that can be implemented to provide improvement efforts towards social dimension attributes to support the sustainability of vaname shrimp farming businesses in the Bantan District include providing encouragement and motivation for farmers to be actively involved in managing resources related to cultivation so that all information, policies and regulations related to vaname shrimp cultivation can be accepted and implemented properly, provision of legal protection and assistance will help to minimize the occurrence of things that trigger conflict so that it is expected to be able to provide policy management for conflict frequency attributes.

Institutions in the shrimp farming business in Bantan District provide a measure of the assessment of the extent to which institutions play a vital role in supporting the existence of the vaname shrimp farming business in Bantan District as well as knowing the institutional interactions that are formed due to the existence of the farming business.

The results of the Rap-SF analysis on the institutional dimension show a value of 47.10, as seen in Figure 7, which is classified as less sustainable (25.00-49.99). The less sustainable status in the institutional aspect is an important concern that must be improved by the government/stakeholders. Proper management is expected to improve the sustainability of the vaname shrimp farming business in the Bantan District.

The low index of sustainability of legal and institutional dimensions in traditional shrimp farming is influenced by the attributes of lack of understanding of the availability of regulations on whiteleg shrimp farming/coastal area management regulations/cultivation business permits, availability of zoning documents, and consistency of land use with the Urban Land Use Plan and the absence of supervision on whiteleg shrimp farming activities in coastal areas[5].

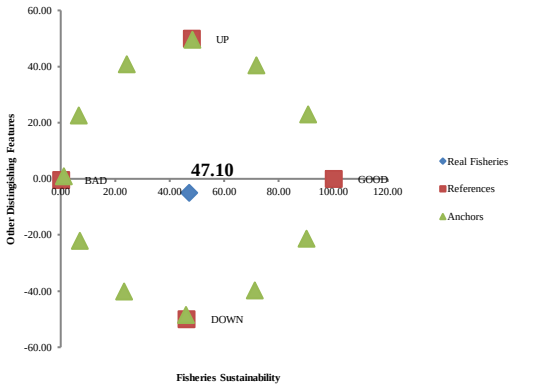

Figure 7. Status of sustainability of institutional dimension

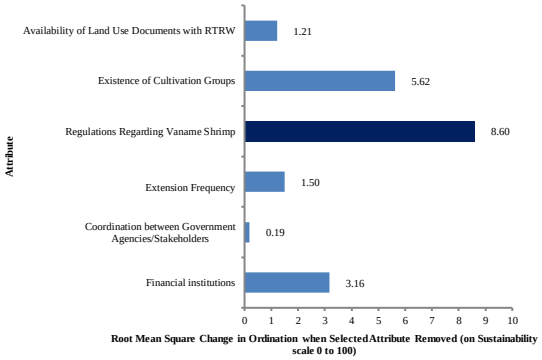

Figure 8. Attribute sensitivity in the institutional dimension

Sensitivity analysis on the institutional dimension aims to provide management priorities that will support the sustainability status of vaname shrimp farming businesses in the Bantan District on the institutional dimension. Based on the results of the sensitivity analysis, the RMS value of each institutional dimension attribute can be seen in Figure 8. The RMS value shows the level of influence of the attribute on the sustainability index value. The largest RMS value indicates the attribute that has the greatest influence, and vice versa. The attribute with the smallest RMS value also has a small influence on the sustainability index value. The attributes are taken until the maximum cumulative value reaches 75% so that sensitive attributes are obtained for the sustainability of the institutional dimension of the vaname shrimp farming business in Bantan District, namely the regulatory attributes related to vaname shrimp.

The management strategy in improving the institutional dimension that the government/related stakeholders can carry out is to provide appropriate sanctions to business actors who do not run vaname shrimp farming businesses in accordance with established regulations and provide awards to farmers who have carried out cultivation efforts in accordance with the rules so as to motivate for vaname shrimp farmers to provide appropriate sanctions.

Technology Dimension

Shrimp farming businesses with intensive pond types require technological support that can help the vaname shrimp cultivation process run optimally. The difference between intensive ponds and other types is marked by high stocking density technology and the use of other supporting technologies such as waterwheels, nanobubble electricity infrastructure, and even modern feed technology. Adequate technology will help form a good vaname shrimp farming business and will produce quality shrimp production. Procurement of technology and its mastery will support the concept of sustainability of the vaname shrimp farming business because it will encourage effective and efficient vaname shrimp production.

The results of the Rap-SF analysis on the technology dimension show a sustainability index value of 63.35 (Figure 9), which is classified as fairly sustainable (50.00-74.99). The available technology used in the farming business in Bantan District provides sustainable value that will support the sustainability of the vaname shrimp farming business now and in the future. The sustainability index value is in the range of 51.00-75.00, which means it is quite sustainable. The sustainability index value shows that the existence of technology in the area is quite supportive in managing cultivation.

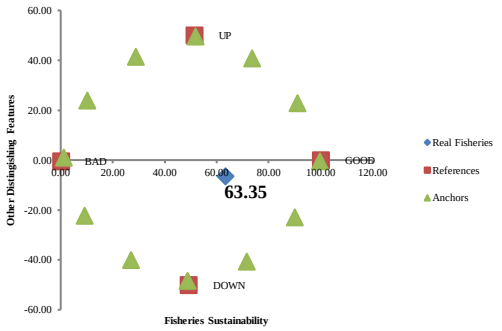

Figure 9. Status of sustainability of technological dimension

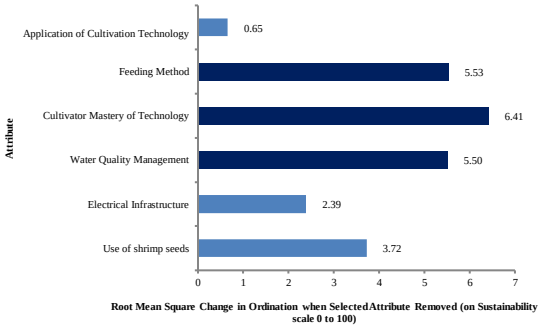

Figure 10. Attribute sensitivity in the technological dimension

A sensitivity analysis is needed to determine the attributes that influence the sustainability of the technology dimension. The results of the sensitivity analysis obtained the Root Mean Square (RMS) value of each attribute of the technology dimension, which can be seen in Figure 10.

The RMS value indicates the level of influence of the attribute on the sustainability index value. The largest RMS value indicates the attribute that has the greatest influence, and vice versa; the attribute with the smallest RMS value also has a small influence on the sustainability index value of the shrimp farming technology dimension in the Bantan District. Based on the maximum cumulative value, which reached 75% on the Pareto analysis, the sensitive attributes were obtained. Among others, attributes of farmer mastery of technology, attributes of feeding methods, and attributes of water quality management. The strategy for managing the attributes of farmer mastery of technology can be done by providing training for farmers who are not yet skilled and experienced. This training can encourage farmers to improve their ability to cultivate vaname shrimp.

Goodness of fit analysis

The stress value and coefficient of determination are used to understand the extent of the accuracy of the sustainability index value. These metrics help determine whether additional attributes are required to improve the accuracy of the five dimensions analyzed, ensuring that the results are scientifically valid and reliable. The stress value obtained from the five dimensions, such as the ecological, economic, social, institutional, and technological dimensions, is less than 0.25[18]. The R-Square value of the five dimensions shows a value close to 1 or >90% can be seen in Table 2

Table 2. Stress Value and R^2

No	Dimensions	Stress Value	R2
1	Ecological dimension	0.16	0.93
2	Economic dimension	0.15	0.93
3	Social dimension	0.15	0.93
4	Institutional dimension	0.14	0.94
5	Technology dimension	0.15	0.93

4. CONCLUSION

The sustainability of each dimension in the vaname shrimp farming business in Bantan District shows a sustainability index of the ecological dimension of 47.27 (less sustainable), the economic dimension of 59.55 (quite sustainable), the social dimension of 52.88 (quite sustainable), the institutional dimension of 47.10 (less sustainable) and the technological dimension of 63.35 (quite sustainable). Sensitive attributes in the vaname shrimp

farming business in Bantan District include the attribute of farmer involvement in fisheries resource management, the attribute of conflict frequency, the attribute of regulations related to vaname shrimp, the attribute of the shrimp selling price, the attribute of technological mastery of technology and the attribute of the number of wages.

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