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Environmental Impact of the Intensive System of Vannamei Shrimp (*Litopenaeus vannamei*) Farming on the Karimunjawa-Jepara-Muria Biosphere Reserve, Indonesia

Agus Roma Purnomo [a], Mufti Petala Patria [b, *], Noverita Dian Takarina [b] Mahawan Karuniasa [a]

[a] *Postgraduate Department, School of Environmental Science, Universitas Indonesia, Jakarta, 10430, Indonesia*
[b] *Faculty of Mathematics and Natural Science, Universitas Indonesia, West Java, 16424, Indonesia*
*Corresponding author: *mpatria@sci.ui.ac.id*

Abstract— The Karimunjawa-Jepara-Muria area, with a landmass of 1,236,083.97 ha, was recently designated as a biosphere reserve by UNESCO on October 28, 2020. However, this area is currently facing challenges in the form of increasing intensive shrimp pond development. The wastewater from shrimp pond aquaculture can adversely impact the waters of the Biosphere Reserve Core Zone. This research aimed to investigate the environmental impacts of pond activities on the Karimunjawa Biosphere Reserve. Sampling was done in July-December 2020. Samples were 54 respondents from society and 11 farmers. Questionnaires were distributed to the respondents to gain information about the environmental impact of the intensive pond, while water quality parameters (DO, salinity, temperature, nitrate, and phosphate) were measured from 3 stations; each station consists of 12 sampling points. Questionnaires were analyzed using a Linkert scale and SPSS. The results showed that based on water quality measurement, most of the parameters showed values that were below the threshold, except the nitrates and phosphate. The harmful impact of shrimp pond activities in the Karimunjawa-Jepara-Muria Biosphere Reserve on the ecology was 34.81% in the form of pressure on marine biota and agriculture, while on social it was 34.22% in the form of social conflict in the community. Ponds also have not significantly improved the surrounding community's economy; the effect is only 9.36%. Therefore, the strategies needed to deal with environmental impacts are creating the effective Wastewater Treatment Plant (WWTP), increasing the human resources of farmers, and monitoring or supervising the sustainable pond management application.

Keywords— **Shrimp farming; water quality; environmental impact; Karimunjawa-Jepara-Muria biosphere reserve.**

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I. Introduction

Globally, aquaculture is growing rapidly, with the production of 80 million tons in 2016, which was higher than the 76.1 million tons previously obtained in 2015 [1]. An increase also occurred in Asia's coastal areas [2]. Meanwhile, in Indonesia, aquaculture, especially shrimp farming, flourished in 1980 [3]. However, the rapid growth of aquaculture raises questions on the impact of environmental sustainability when the shrimp pond wastes are not properly managed [4] [5]. Although aquaculture activities are located outside the conservation area (Biosphere Reserve's core zone), the shrimp ponds built right in the buffer zone will affect the biosphere reserves. Indonesia's Karimunjawa-Jepara-Muria Biosphere Reserve is invaluable due to its high biodiversity value, including genetic diversity, species, and ecosystems.

Furthermore, the area recorded more than 318 types of flora and 888 fauna inhabited [6]. Currently, ponds are experiencing threats due to the flow of shrimp pond waste into this conservation area's waters. Intensive shrimp pond waste produces organic waste in sediment, colloids, and suspended and dissolved solids [7], [8]. The organic waste will be degraded by aerobic microbes that use available dissolved oxygen (DO). However, excessive amounts of organic waste will increase microbial activity, reducing dissolved oxygen (DO) in waters [9]. The emergence of pond cultivation has led to increased turbidity in the waters of Al-lit east of the Red Sea [10]. Furthermore, shrimp farming ecologically pollutes agriculture and fisheries in coastal areas[11] [12].

There is an urgent need to reduce environmental impacts in the Karimunjawa Biosphere Reserve due to the potential threats to pond activities. This research is an effort to reduce the potential environmental impacts and threats associated with preserving biodiversity.

Several preliminary studies discussed shrimp pond management strategies. According to these studies, sustainable cultivation principles must be considered to minimize the environmental impact of shrimp pond cultivation [13]. Studies showed that combating rotational shrimp farming technology with vegetable crops is ideal to achieve a sustainable goal. This is due to its ability to improve the socio-economic conditions of the community and preserve the ecology [14]. Research has shown that the application of polyculture technology, which is the cultivation of various types of fish simultaneously and place also helps in alleviating this condition [15], [16]. Polyculture cultivation has been widely developed in Danding, China [17]. Some of the species developed were the Chinese Shrimp (*Penaeus Chinensis*) cultivated with jellyfish (*Rhopilema esculenta*), and shells (*Sinonovacula constricta*) [17]. The shrimp polyculture cultivated with tilapia is more effective compared to the use of mullet fish [16]. However, the cultivation of vannamei shrimp and milkfish in different systems with seaweed (Gracilaria sp.) as a biofilter, can increase production and sustainability [18]. Furthermore, seaweed (Gracillaria sp.) are also planted to improve the inlet and outlet of the environmental improvement in pond areas in order to restore the water value. Sustainable shrimp farming is managed internally and externally with the development of integrated multitrophic aquaculture (IMTA) [19]. In this system, nutrients and natural elements found in wastewater are used and absorbed by individuals with subordinate trophic stages [20]. This process makes it possible for seaweed and bivalves to absorb shrimp culture waste [20]. Furthermore, shellfish growth can be increased in an integrated multitrophic system, with a rise in shrimp productivity due to secondary species, particularly those related to water quality improvement. The survival and growth rate increased with a decrease in pathogenic bacteria *Vibrio harveyi* in polyculture shrimp culture using mollusks compared to monoculture [20]. Another sustainable cultivation system is obtained using biofloc technology (BFT) by minimizing water exchange, feed efficiency, and inhibiting disease progression [21]. Technically, shrimp cultivation using biofloc technology function as additional feed and helps in the growth of microorganisms[22]. The right composition of bacteria and algae are more beneficial for aquaculture [23]. However, in contrast to the biofloc system, the recirculation technology (RAS) system does not change the water [21]. Waste is physically and chemically processed through recirculation to become a biologically safe and hygienic product [24].

This research differs from many previous studies, due to the location and variables utilized. For instance, other studies were carried out in areas far from conservation, while this research was conducted in the intensive shrimp ponds adjacent to conservation areas. The variables used are integrated variables, with the shrimp pond performance analyzed to determine the water quality and environmental impacts. This study emphasizes environmental science's perspective, such as the management of ponds by minimizing environmental impacts and a balance between economic and interests.

This study aims to analyze the potential environmental damage to biosphere reserves due to shrimp pond activities from the perspective of environmental science, which combines social and economic aspects of the surrounding community. This research provides a sustainable pond management strategy to reduce the various adverse environmental impacts.

This article contributes to the empirical findings of how many the environmental impacts of shrimp farming activities around the Karimunjawa-Jepara-Muria Biosphere Reserve, Indonesia, as well as to formulate management strategies to minimize environmental impacts. This finding is expected to be a global comparative study, especially to determine the environmental impact of pond activities in other conservation areas in the world.

II. Material and Methods

A. Research Location

This research was carried out in July-December 2020 at Karimunjawa-Jepara-Muria Biosphere Reserve, Indonesia.

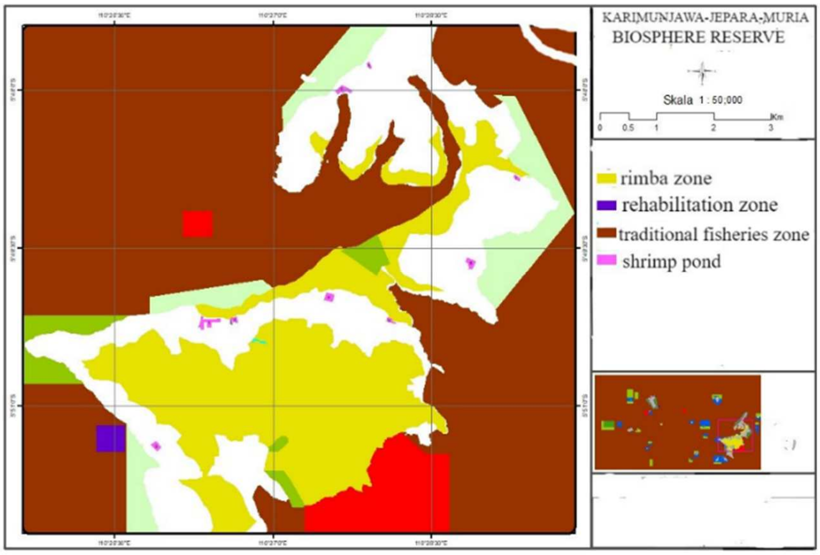

Fig. 1 Research Location Map

The location consists of three stations, namely Karimunjawa pond, canal waters (far from the pond), and Tambak Kemujan, which are denoted as stations I, II, and III. The consideration of determining the three stations is based on the proximity of the pond location to environmental conditions in the form of a mangrove ecosystem. Research stages flowchart depicted in a research flow diagram described in Figure 1.

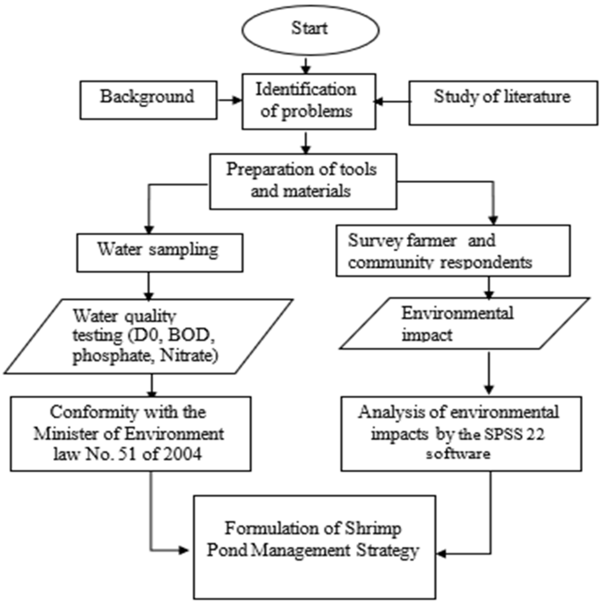

Fig. 2 Research Stages Flowchart

The explanation of the research flow diagram above begins with the background of this research, then studies the literature and identifies problems that this research needs to be carried out. After that, prepare tools and materials. The next step is surveying water samples and distributing questionnaires. Analyze the data and finally formulate a sustainable pond management strategy. The tools and materials used in this research are described in Table I.

TABLE I
TOOLS AND MATERIALS

No	Parameter	Unit	Tools and Method
1	Temperature	ºC	Thermometer
2	Salinity	º/oo	Rz117 Refractometer
3	DO	mg/l	Pro 20 DO meter
4	BOD	mg/l	SNI 6989.72-2009
5	Nitrate	mg/l	Standard Method 4500NO3E
6	Phosphate	mg/l	SNI 06-6989.31-2005

B. Data Collection and Analysis

Data collections were done using quantitative and qualitative research. Quantitative method used to analyze the quality of waters. Meanwhile, the qualitative method was used to analyze the environmental impacts on the surrounding community due to shrimp farming activities viewed from ecological, social, and economic aspects. We also formulated sustainable shrimp pond management strategies. Data related to the environmental impact were collected by distributing questionnaires to 54 community respondents and 11 farmers with in-depth interviews conducted on key informants.

C. Water Sampling

Water samples were taken in shrimp ponds from 3 stations with 12 sampling points in each station. Water quality parameters such as temperature, salinity, pH, and dissolved oxygen (DO) were measured *in-situ*, while for TSS, BOD, phosphate, and nitrate analysis, the water samples were inserted into a 600 ml bottle, then tightly closed and put into an icebox. These samples were then brought to the Center for Testing and Equipment (BP2) laboratory of Bina Marga and Cipta Karya, Central Java Province. Furthermore, results on physical and chemical parameters were compared to the predetermined quality standards for seawater by Ministry of Environment law No. 51/2004. The locations and quantities of water samples are described in Table II.

TABLE II
LOCATION AND QUANTITY OF WATER SAMPLES

No	Location	Sampling Points	Tot	Coordinates
1	Station 1			5^0 50’ 0,271”S-
	- Pond inlet	1,2,3	3	110^0 26’
	- Pond	4,5,6	3	33,913”T
	- Pond outlet	7,8,9	3	
	- Waters of Biosphere Reserve	10,11,12	3	
2	Station II	13,14,15,16		5^0 49’
	- Waters of Biosphere Reserve	,17,18,19,2 0,21,22,23, 24	12	24,174”S-110^0 27’ 53,478”T
3	Station III			5^0 48’ 1,644”S-
	- Pond inlet	25,26,27	3	110^0 27’
	- Pond	28,29,30	3	39,706”T
	- Pond outlet	31,32,33	3	
	- Waters of Biosphere Reserve	34,35,36	3	
	Total		36	

D. The Environmental Impact

The Environmental Impact Measurement of the independent variable (x) and shrimp ponds are used to determine the dependent variables' changes. The dependent variable (Y) is Y1: Ecological conditions, Y2: Community social conditions, and Y2: Community economic conditions. Questionnaire data analysis with the SPSS 22 software is used to decide the implication of the consequence of variable X on Y. Furthermore, Asymmetric Correlation, the correlation between the Independent and Bound variables, is also used. The steps used to analyze the research objectives are as follows:

- Make a Likert scale of the answers to each question from the questionnaire, with gradations used to determine the very positive to very negative values.
- Formulation *of Shrimp Pond Management Strategy* Based on the analysis of environmental impacts, several factors need to be considered to enhance shrimp culture management. An instance is the Management Strategy achieved by designing a pond development model and related policies from the government to reduce environmental impacts. This process was carried out using the interview method with the key informants assigned to the formation of policy strategies.

Furthermore, the analysis is action-oriented by paying attention to two essential aspects, namely internal capabilities and dynamic external factors, to achieve predetermined goals.

III. RESULTS AND DISCUSSION

A. Description of the Research Area

The Karimunjawa-Jepara-Muria area, with a landmass of 1,236,083.97 ha, was recently designated as a biosphere reserve by UNESCO on October 28, 2020, to conserve the biodiversity. This includes conservation areas, such as the National Park, Muria Protected Forest, and Celering Nature Reserve, the buffer zone, and areas outside the conservation and buffer zones as a transition area. Administratively, the proposed reserve is located in 3 districts, namely Jepara, Pati, and Kudus Regencies in Central Java Province.

Karimunjawa Islands is administratively one of the largest districts in Jepara Regency, consisting of 27 large and small islands. The Biosphere Reserve's core area is the National Park, a conservation region and an archipelago in the Java Sea with a total area of 111,625 hectares. This area was determined based on the verdict of the Minister of Forestry No.78 / Kpts II/1999 dated February 22, 1999. It is a marine conservation area, which represents the integrity and uniqueness of the north coast of Central Java. Shrimp farms are located in the buffer area of the reserve and were reborn in 2016 after collapsing in 2000. According to preliminary studies, shrimp ponds experienced a boom from 1990 to 2000 with the cultivation of tiger prawns and giant prawns. However, shrimp ponds' tracks were left behind for 20 years and are now starting to be covered with mangrove vegetation.

Recently, there has been an increase in shrimp pond cultivation activities around the Karimunjawa. There are 15 points of pond locations covering an area of 27.24 hectares. Concern arises because the shrimp pond is located adjacent to the Core zone of Karimunjawa-Jepara-Muria Biosphere Reserve. Some of the ponds do not have a sewage treatment pond. Some already have sewage treatment ponds, but the processing has not been optimal so that the shrimp farming activities are thought to have the potential to cause environmental impacts in the form of decreasing water quality in Karimunjawa National Park. Shrimp pond conditions are shown in Figure 3.

Fig. 3 Condition of shrimp ponds in Karimunjawa.

B. Water quality

The characteristics of water quality studied in the Karimunjawa pond comprises of dissolved oxygen (DO), BOD5, phosphate and nitrate parameters. The results of the analysis of water quality characteristics are as follows.

TABLE III
RESULTS OF WATER QUALITY ANALYSIS AT 36 SIDE POINTS

Point	Salinity (‰)	Temperature (^{0}C)	DO (mg/L)	BOD (mg/L)	Nitrate (mg/L)	PO_4^{3-} (mg/L)
1	31	31	3.2	4.48	1.00	0.58
2	31	30.52	3.3	1.84	1.23	0.44
3	33	30	3.27	1.84	0.82	0.14
4	30	29.6	5.3	1.52	1.06	2.44
5	35	30.7	4.99	7	1.06	0.11
6	32	29.2	4.99	2.64	1.56	2.74
7	32	29.4	4.27	1.6	2.09	7.03
8	28	30.5	3.98	2.08	1.97	6.18
9	27	29.8	3.81	1.28	1.54	3.72
10	30	30.9	3.93	1.84	1.56	0.45
11	30	29.8	2.23	5.44	1.37	0.87
12	32	28.6	3.72	1.2	0.99	1.34
13	32	31.2	2.91	0.96	1.65	0.01
14	33	31.3	3.25	0	1.32	0.01
15	34	31.1	3.4	0.24	1.49	0.01
16	33	31.3	3.74	0	1.00	0.06
17	34	31.3	3.57	0.2	1.05	0.01
18	32	31.2	3.81	1	1.15	0.01
19	33	31.5	3.42	0.28	0.70	0.05
20	33	31.2	3.71	2.84	1.21	0.01
21	33	31.2	3.86	1.84	0.50	0.01
22	33	31.2	3.63	0	0.77	0.01
23	33	30.9	3.79	0.64	0.97	0.01
24	33	30.9	3.61	0.4	0.77	0.01
25	32	30.1	3.9	1.12	1.04	0.31
26	32	30.9	6.41	2.36	0.62	0.30
27	31	30.9	4.46	2.84	0.50	0.03
28	35	31.1	3.35	5.68	2.20	5.84
29	35	31.2	2.35	4	1.55	5.24
30	35	31.2	2.79	5.6	2.34	4.55
31	35	31.2	2.01	5.6	1.38	6.11
32	35	31.3	1.98	2.08	1.38	6.27
33	35	31.3	1.74	3.2	1.52	4.70
34	35	31.2	2.94	3.08	1.23	0.34
35	35	31.2	2.81	0	1.60	0.10
36	33	30.9	2.55	0.24	1.61	0.06

1) Temperature: Overall, the temperature in Karimunjawa ranges from 28,6–31,3ºC. The highest temperature is at stations 14, 16, 17, 32, 33 at 31,3 ºC.

2) Salinity: The salinity value in Karimunjawa ranges from 27–35 ‰. The lowest salinity value is at point 9. The highest salinity value is at point 28,29,30,31,32, 33,34,35, this is presumably because this point is the outermost area of the bay so the effect of fresh water at that point is less when compared to other stations. High salinity and poor pond productivity have a negative impact on shrimp production and economic yields [18].

3) DO analysis: The environmental quality standard for marine biota for DO parameters is above 5 mg / L. Table II shows that most of the DO concentrations did not meet the environmrntal water quality standard from all observation points. This indicates that the ponds and Biosphere Reserve waters lack oxygen, which negatively affects marine life.

4) According to the Minister of Environment law No, BOD analysis: The water quality standard for marine life. 51 of 2004 is 20 mg / L. This also indicates that the BOD5 remains below the quality standard at all points. However, the BOD concentration value tends to be close to the quality standard. The concentration at stations I and III have a higher average value than II, which acts as a standard station. The high BOD value at the two stations is due to shrimp farming activities that provide a high pollutant load around the area. High BOD content in wastewater decreases the amount of oxygen in the water and kills fish, thereby producing a bad smell. The greater the BOD concentration of water, the higher the organic matter.

5) Nitrate Analysis (NO3-): The standard quality of nitrate for marine life is 0.008 mg /L, the research location has a nitrate concentration ranging from 0.5-2.34 mg / l, with a high concentration that passes at all stations. The highest nitrate concentration was at stations I and III, while the lowest was at Station II, which acts as the control station. Nitrate levels in the waters are strongly influenced by nitrate intake from fecal waste and feed [25]. Shrimp excrete the end product of feed protein metabolism mainly in the form of NH2 [26].

6) Phosphate Analysis (PO4 3-): Phosphate concentration values ranged from 0.01 to 0.18 mg /L. The phosphate measurement data shows that all observation stations exceeded the threshold set in the environmental quality standard for marine life, which is 0.015 mg / L. The highest phosphate concentrations are at Stations 1 and III, while the lowest is at Station 1I. This indicates that the pond activity causes high phosphate concentrations in water, thereby leading to eutrophication. In addition, intensive shrimp pond waste can cause eutrophication [27]. Phosphate is found in very small quantities in natural waters and acts as a mineral and organic compound. When the amount increases, it becomes dangerous for aquatic biota to habitat.

C. Environmental impact due to Shrimp Farming Activities

Generally, it is necessary to predetermine the relationship between the variables of the pond with ecological, social, and economic conditions. Table IV shows the correlation or relationship between shrimp pond activities with ecological and social conditions.

TABLE IV
CORRELATION BETWEEN SHRIMP PONDS, ECOLOGICAL, SOCIAL, AND ECONOMIC

Correlation					
		Shrimp ponds	**Ecology**	**Social**	**Ecom**
Shrimp ponds	Pearson Correlation	1	.590**	.585**	.306*
	Sig. (2-tailed)		.000	.000	.024
	N	54	54	54	54

1) Ecology: The relationship between ponds and ecology in the Karimunjawa Biosphere Reserve, Jepara Muria is shown in Table III. The 2-tailed significant value between ponds and ecology is 0.000 less than 0.05, and the calculated r-value is 0.590 greater than r-table at 0.273. This means that there is a significant relationship or correlation between pond variables and ecology. The relationship between ponds and ecology is positive (r-count is positive). Therefore, better pond management can improve ecological conditions. In addition, to determine the impact of pond activities on ecological conditions, the formula for the coefficient of determination used is (0.590) 2 x 100% = 34.81%. This means that the impact of ponds on the ecology is 34.81%.

Ecologically, the impact of ponds in the Biosphere Reserve pollutes agricultural land in coastal areas. Figure 4 shows the results of respondents' answers regarding pond pressure on agricultural land.

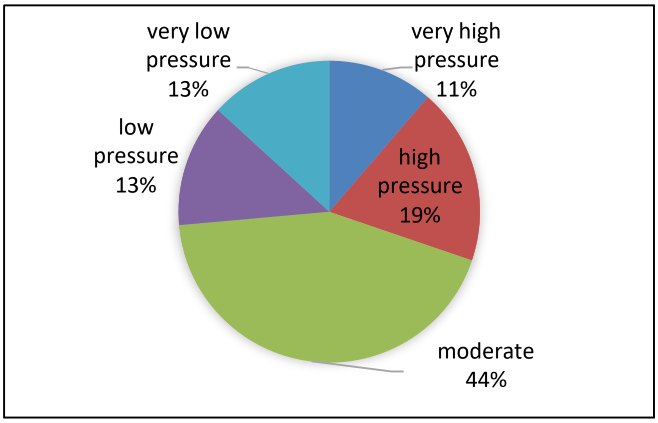

Fig. 4 Impact of ponds on agricultural land

According to the chart, 44% of the respondents stated that the ponds had put moderate pressure on agricultural land and 19% reported that the ponds gave high pressure. The entry of pond salty water into agricultural land causes a decrease in productivity in coastal areas[28]. Furthermore, the impact of ponds on ecology indicates the occurrence of eutrophication. Water is eutrophic, assuming the total phosphorus (TP) concentration is higher than 0.1 mg / L, the waters at stations I and II have a phosphate concentration which is classified as eutrophic. Phosphorus is a key element among the main nutrients (carbon (C), nitrogen (N), and phosphorus (P)) in the eutrophication process, which comes from 100% artificial vegetable feed ingredients. This leads to the accumulation of post-harvest waste, which has a high burden on the environment. Leftover feed in the form of organic matter has the ability to disrupt the balance of the coastal ecosystem. For example, a shrimp pond near Estuaria Guarairas in Brazil has the potential to cause eutrophication by removing waste organic matter and nutrients. This is similar to the coast and coral reefs of China's Ne Heinan coast. A large amount of shrimp pond waste which is rich in dissolved organic and inorganic matter, is dumped on the NE coast of Hainan and causes eutrophic conditions in coastal waters [2]. In addition, the accumulation of organic elements in coastal waters increases the algae population [29]. The increase causes water conditions to become oxygen, disturbing the marine biota community more extremely and leading to mass death in coastal areas. Untreated pond culture waste is dangerous in coral reefs, seagrass, and mangroves[2]. Studies further showed that eutrophication also affects bacterioplankton's diversity and composition, which is a bacteria that live as plankton and play an important role in nutrients (nutrient cycle) in marine ecosystems [23]. It also functions as a decomposer in the marine ecosystem. The effect of eutrophication can change the stability of the bacterioplankton community; therefore, it has the potential to cause diseases.

Furthermore, organic waste in the anaerobic layer produces many NH3 and H2S compounds in the water at certain toxic concentrations [30], [31]. Moreover, the Karimunjawa Biosphere Reserve, which is in the form of an archipelago, consists of small islands that are vulnerable to changing environmental conditions. The tendency of environmental changes due to the activity of large shrimp ponds is because the pond management system in Indonesia is sustainable. It also discharges pond waste into the waters without being properly managed. The impact of ponds on aquatic biota is shown in Figure 5.

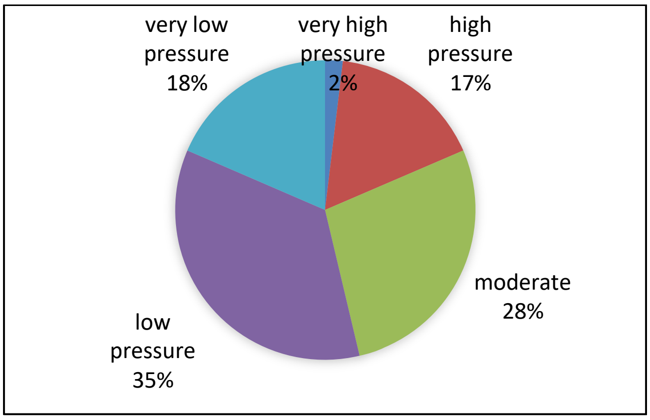

Fig. 5 Impact of ponds on Marine Biota

According to figure 5, 35% of the respondents stated that the ponds in Karimunjawa provided low pressure. Meanwhile, 28% reported that liquid waste disposal into the environment, especially seawater bodies, has broad implications for biota. The waste from the remaining shrimp feed contains protein which includes biodegradable pollutants and affects the decreasing oxygen available in water bodies. Protein and fat have great potential for water enrichment (eutrophication). In comparison, lack of oxygen in water bodies causes death in aquatic biota (especially fish and shrimp). According to studies, excessive water enrichment affects the mass growth of phytoplankton (plankton bloom) on the waters' surface. Another effect of shrimp waste is the foul odor of the decomposition of protein and fat by rotting bacteria.

2) *Social:* The relationship between the pond and the social condition of the community is shown in Table II. The result shows a significant value (2-tailed) of 0.000 < 0.05 between ponds and social, with a calculated r-value of 0.585> r-table 0.273. This means that there is a significant relationship or correlation between the pond variables and the social community. In addition, the relationship between the ponds and the social community is positive. Therefore, better pond management has the ability to improve the social conditions of the community. Meanwhile, ponds on social conditions in the Karimujawa Biosphere Reserve, Jepara Muria, were 34.22%. The presence of ponds creates conflicts as shown in Figure 6.

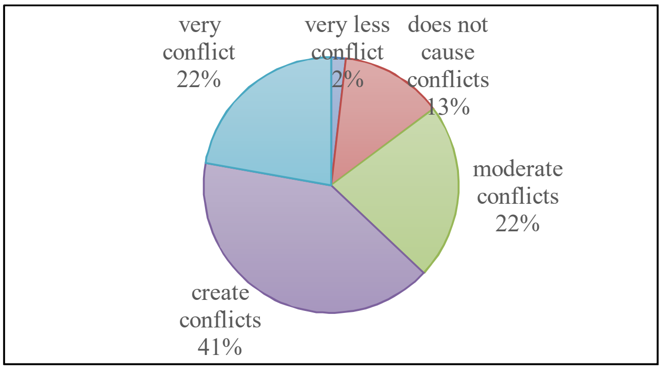

Fig. 6 Impact of ponds on conflict (pros and cons) in the community

Figure 6 shows that 41% and 12% of the respondents stated that ponds and shrimp farming caused conflict. This analysis is in accordance with the conflict with residents associated with those that are pro and contra with the existence of shrimp ponds[13]. According to the respondents, shrimp ponds can damage the aquatic environment and disrupt tourism.

3) *Economy:* The relationship between the ponds and the economy is shown in Table II. The sig value (2-tailed) between ponds and the economy is 0.024 <0.05, and the calculated r-value is 0.306> r table 0.273. This means that there is a significant relationship or correlation between the pond variables and the economy. The relationship between ponds and the community's economy is positive (r count is positive). Therefore, the greater the ponds, the better its ability to improve the community's economy. The result also showed that ponds on the community's economy were 9.36% and very small (negative impact). The economic benefits are mostly enjoyed by farmers that come from outside Karimunjawa. While the positive impact of the existence of shrimp farming increases the community income from leasing land for ponds, a small portion of the community works as laborers such as shrimp farmworkers, pond maintenance, and harvesting personnel [11].

D. Strategies to minimize environmental impact

Sustainable development is the absolute responsibility of every pond entrepreneur to maintain the preservation of biodiversity and environmental functions in supporting the inherent life [32]. Therefore, pond entrepreneurs need to carry out this activity by minimizing waste. There are three (3) strategies for sustainable pond management. The first strategy is implementing Standard Operating Procedures (SOP) for waste disposal by having a good Wastewater Treatment Plant (WWTP). The intensive shrimp pond consists of 4 parts. In the first part, sedimentation is carried out to dispose of the shrimp waste. This ensures that the TSS (total suspended solids) levels and the bad smell from H2S are decreased. The remaining sediment is turned into fertilizer. The remaining wastewater enters the second part from the first pond with the oxygenation ability to increase oxygen and reduce BOD. The third part changes nutrients into eutrophication for the organism's benefits. The fourth part is used as a storage unit for disposal to the sea.

The second strategy is the development of human resources quality for aquaculture actors [33]. This human resource development can be carried out by the Regional Government and the Ministry of Environment and Forestry through training and socialization on sustainable shrimp farming. The third strategy is the regulation and monitoring of the government's culture system, especially in enforcing RTRW and examining the Performance of WWTP. Sustainable shrimp farming consists of internal and external management. Internal management, which is in environmental, feed, and wastewater management, is used to overcome internal problems that can endanger coastal areas. External management, which the government carries out, private sector, and NGOs [34], is in the form of socialization and guidance. Similar to in Northern Vietnam, the aquaculture farmers are guided by private parties and commercial companies, especially in the use of antimicrobials in shrimp farming[34]. While internal management is carried out by the manager/owner of the pond [35].

In sum, currently the Karimunjawa-Jepara-Muria Biosphere Reserve is in a state of danger due to decreased water quality due to intensive shrimp pond activities. To preserve the Biosphere Reserve, sustainable management of shrimp ponds is required.

IV. CONCLUSION

In conclusion, most of the concentration of water quality parameters were still below the seawater quality standard, except for phosphate and nitrate. Shrimp farming activities in Karimunjawa-Jepara-Muria Biosphere Reserve have adversely impacted the environment's ecology, society, and economt. The impact of ponds on the ecology is 34.81% in the form of a decrease in water quality, characterized by high phosphate and nitrate concentrations, which causes eutrophication. There is pressure on the agricultural sector and marine life. Socially, it has an influence of 34.22%, which causes conflict in the community. Economically, it has not yet created welfare in the community. The effect of ponds on the community's economy is only 9.36%. Management strategies to minimize the environmental effects are needed by making optimal WWTPs, developing human resources, and closely monitoring implemented regulations.

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