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Shrimp pond suitability index (SPSI) in the north coast of Sumenep Regency

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Abstract. Utilization of coastal areas for aquaculture in the Regency is currently starting to increase and exceed the allotment of space in coastal areas. However, some ponds change the mangrove ecosystem and do not ignore the environmental impact. Shrimp production is currently still below the environmental carrying capacity which can still be increased. The objectives of this study were: to analyze the land suitability of traditional, semi-intensive, and intensive shrimp ponds that meet the criteria of land suitability and environmental carrying capacity, and to formulate priorities for environmentally friendly alternative aquaculture technologies. This study uses a field survey to analyze the socio-economic community and land use through interviews with ten cultivators and business actors spread across four coastal districts. The research resulted in an analysis of the sustainability indicators of shrimp farming in the coastal area of Sumenep Regency. This research contributes to policy makers and the community to pay more attention to the sustainability indicators of shrimp farming in coastal areas.

Keywords: land suitability; pond cultivation; shrimp pond

1. Introduction

Background Pond shrimp farming has become the main livelihood of some coastal communities in Madura, especially in Sumenep Regency, as the 2nd largest shrimp producer country in the world after China, Indonesia is also one of the countries that are vulnerable to climate change [1] is an attractive business opportunity for business actors and investors because of the relatively sizeable operating margin. However, the development of shrimp ponds has recently received the attention of environmentalists because it contributes significantly to the decline in the quality and quantity of the mangrove ecosystem. Clearing some mangrove lands and shrimp farming activities is considered to increase greenhouse gas emissions, encouraging global warming and, ultimately, climate change. Climate change harms the continuity and sustainability of the shrimp farming business itself [2] The development of aquaculture businesses must look at environmental indicators and the sustainability of the surrounding ecosystem. The contribution of shrimp farming on the north coast is possible due to land conversion. The capacity is reported to continue to decline due to the utilization of shrimp farming activities, Indonesia according to [3], have lost 800,000 Ha of mangroves over the last 30 years, and in the next two decades, it is estimated that the potential for mangrove reduction is 600,000 Ha. Differences in the composition of phytoplankton species in ponds are influenced by the availability and design of nutrients [4]. The types and abundance of phytoplankton differ between intensive, semi-intensive, and traditional ponds.

Given the link between mangrove forest conversion and the management of aquaculture areas as described above, the development or expansion of aquaculture areas must be integrated with coastal



Table 1. Aquatic suitability scoring (Wibowo, 2006).

Total Score	Conformity Level	Water Quality
43 – 63	Very suitable	Potential has no inhibiting factors
21 – 42	Suitable	Meets the minimum requirements
< 21	Conditionally compliant	Has a limiting factor, needs special treatment

management so that the principle of sustainability for both the pond business and the surrounding environment is maintained. The control of an aquaculture area in the coastal zone must meet the regulations and rules of sustainable and environmentally friendly development to preserve the quality of the environment and other ecosystems in the coastal area. Environmental problems are like two currencies for aquaculture activities. On the one hand, it determines the success of the production of business continuity and, on the other side determines the damage to different ecosystems. Until now, there are no specific rules related to the protection of coastal ecosystems, but the agreement of the nations in the Sustainable Development Goals (SDGs) to increase aquaculture production must be carried out in an environmentally friendly manner and minimize the cost of environmental damage. The mangrove ecosystem on the coast of Sumenep Regency is spread over seven coastal sub-districts such as Pasongsongan, Ambunten, Dasuk, Batu Putih, Batang-Batang, Dungkek, and Gapura Districts. Mangrove ecosystems with a reasonably large area are found in Dungkek District and show that shrimp farming activities in ponds convert mangrove land.

2. Research method

The general objective of this research is to formulate the utilization of the shrimp aquaculture area so as not to convert the mangrove forest. The coastal resources of Sumenep Regency generally consist of several natural and artificial ecosystems that are dynamic and complex in use and must pay attention to the environment. The specific objectives of the research carried out are:

1. It was analyzing land suitability for traditional, semi-intensive, and intensive shrimp ponds that meet the criteria for land suitability for shrimp ponds.
2. Analyzing the priority of alternative technology factors that most influence the productivity of shrimp aquaculture.

The data collected includes primary data and secondary data. Primary data is obtained from the results of surveys/observations in the field equipped with measurement tools. Secondary information is obtained through the effects of references from several agencies related to the research. The class interval will be determined based on the division of existing values into four with equal interval so that using the following equation (1) based on Aryati [5], where:

$$N/J = - h \quad (1)$$

N_{max} = total maximum weight value at location

N_{min} = total minimum weight value at location

Based on the calculation of the class interval as formulated in equation (1), the classification of pond land suitability is divided into categories lass S1: very suitable (highly suitable) this area has characteristics that are very suitable for the development of shrimp ponds. There are no severe barriers that require special treatment and only have insignificant boundaries and no significant effect.

Table 2. Scoring and weighting of land suitability for shrimp cultivation.

No	Parameter	Range	Number (N)	Weight (B)	Score (NxB)	Reference
1	Temperature (°C)	25 – 32	3	3	9	New (2002)
		12 – 25	2		6	
		< 12 or > 32	1		3	
2	Salinity (ppm)	10 – 20	3	3	9	Widiatmaka <i>et al</i> (2014)
		20 – 35	2		6	
		<10 or > 35	1		3	
3	Depth(cm)	70 – 120	3	2	6	Romadhona <i>et al.</i> (2015)
		80-110 or 120 - 150	2		4	
		< 70 or >150	1		2	
4	Brightness (cm)	30 - 40	3	2	6	Cahyono (2009)
		25 – 30 or 40 – 60	2		4	
		< 25 or > 60	1		2	
5	pH	6 – 8	3	2	6	Widiatmaka <i>et al</i> (2014)
		4 – 6 or 8 – 9	2		4	
		<4 or >9	1		2	
6	DO (mg/l)	4 -7	3	3	9	Widiatmaka <i>et al</i> (2014)
		2,5 – 4	2		6	
		< 2,5	1		3	
7	Nitrate (ppm)	0,3 – 0,9	3	3	9	Ramadhani <i>et al</i> (2016)
		0,9 – 3,5	2		6	
		> 3,5	1		3	
8	Phosphate (mg/l)	>0,21	3	3	9	Ramadhani <i>et al.</i> (2016)
		0,1 – 0,21	2		6	
		0,051 – 0,1	1		3	

S2 class: suitable (moderately suitable) this area has rather serious boundaries for maintaining the level of treatment to be applied. This barrier will increase the input/level of treatment required. S3 class: marginally suitable. This area has severe limitations for maintaining the level of treatment to be applied. The barrier will further increase the input/level of treatment required. Class N: non suitable . This area has a permanent barrier to prevent any possible treatment in the area.

3. Result and discussion

Simple Application of the Concept of Environmentally Friendly and Sustainable Pond Cultivation is a technical approach pattern consisting of a series of integrated activities between shrimp farming activities and planting, maintaining, managing, and preserving mangrove forests. The pond embankment construction system will be robust because the roots of the mangrove trees planted along the embankment will be comfortable for pedestrians to use. After all, it will be covered by a mangrove canopy. Mangrove leaves on *Rhizophora* sp. The existence of mangroves prevents coastal erosion and intrusion of seawater to land, creating a green belt on the coast that can support mitigation and adaptation programs to global climate change. There are three types of traditional ponds, namely the kind of embankment trench, komplangan, and lane. The embankment ditch pattern, where the land is

Table 3. Study of the suitability of shrimp ponds.

Land	Salinity (ppt)	Temperature (°C)	Depth (m)	Brightness (cm)	PH
0	10	27	1,78	24	8,42
1	16	28	1,54	25	8,26
2	12	27	2,31	26	8,11
3	16	28	2,08	27	7,97
4	15	28	1,87	28	7,83
5	20	27	1,66	29	7,69
6	14	26	1,47	30	7,56
7	16	29	1,28	31	7,43
8	15	28	1,09	32	7,30
9	15	27	1,91	33	7,18
10	19	27	1,74	34	7,06
11	16	26	1,58	35	6,95

Table 4. Saturation value at each point of observation.

Station No	Oxygen Observations	Oxygen Calculation Results	Saturation Value
1	3,67	11,03	46,8 %
2	4,73	12,01	60,4 %
3	5,48	10,22	69,9 %
4	5,36	9,50	69,7 %
5	5,14	8,40	66,8 %
6	6,67	10,22	86,7 %
7	6,42	8,77	84,9 %

effectively used to raise shrimp, is only a circular channel, while the middle is overgrown with mangrove trees. In the intensive pond type, shrimp rearing is separate or adjacent to the coastal area.

The parameters used in this research are classified into physical and non-physical parameters. Physical parameters use direct survey methods to obtain water quality data, such as temperature, salinity, acidity/pH. Non-physical parameters in the form of geographical data, such as distance to the beach, rivers, slopes, and soil types, were not surveyed directly in data collection.

The advantages of the traditional type are that the shrimp rearing space is wide enough. Weathered mangrove litter can increase pond fertility and sufficient sun intensity. The disadvantages are that mangrove litter cleaning must be done frequently, and herding fish must do harvesting in one corner of the pond. The ratio of mangrove area and pond area is 80:20 with pond production, which is relatively small because it prioritizes the ecological balance of the waters. The target for shrimp production in Sumenep Regency can still be increased. Still, this target's achievement cannot be achieved by increasing the total area of aquaculture as stated in the Strategic Plan of the service. Increasing land productivity and cultivation technology are efforts that can be made to achieve production targets. Land designated as mangrove protected areas needs to be reforested or reforested. The restoration of mangrove ecosystems on the coast will positively impact the continuity and sustainability of shrimp farming in ponds and, at the same time, restore environmental services.

In the vaname shrimp farming business, the size of the income received by vaname shrimp farmers, both traditional ponds and intensive ponds, is strongly influenced by the amount of production or yield

of vaname shrimp. The selling price of vaname shrimp, which tends to be constant, makes the amount of production and size of vaname shrimp produced are the main factors that affect the income of the vaname shrimp farming business. To achieve the maximum amount of production, optimization is carried out during the vaname shrimp cultivation process so that early harvesting or harvesting is not carried out prematurely. Early harvesting is done because of a disease attack that causes the shrimp to be threatened with death or can't grow anymore. Farmers do this to minimize the losses that will be received. In traditional ponds, the tides of seawater also affect production because when the tide is high, the shrimp can be bottomed by seawater.

3.1. Labor Cost

There are several farmers with the same land area and have a different number of workers. There are two types of labor costs incurred by farmers: monthly labor costs and daily labor costs. Intensive ponds' monthly labor costs consist of pond heads, feeders, drug givers, fry spreaders, mechanics, technicians, technical assistants, guards, cooks, warehouse staff, laboratory staff, and daily labor costs, namely harvesters. Whereas in traditional farmers, the monthly labor cost is one person doing all the activities in the vaname shrimp pond and the daily labor costs are harvesters. The activities carried out by the farmers are spreading fry, feeding, giving medicine, repairing the water opening system, maintaining the stability of the water volume when the tide is low, sewing the shrimp nets that are damaged in several parts so that every other number of workers will increase the number of costs that must be incurred by farmers which will also reduce the income of vaname shrimp farmers intensively and traditionally.

3.2. Land area

Based on the research results in the field, the area of land owned by vaname shrimp farmers is traditionally no different from the area of land owned by vaname shrimp farmers intensively. However, in traditional ponds, the owner does not use the entire pond area to cultivate vaname shrimp. Conventional farmers share their area with the cultivation of other commodities such as fragility and milkfish. So that the area used for vaname shrimp cultivation is narrower than the area of intensive ponds, when farmers increase the area for vaname shrimp cultivation, the farmers must increase the tax or rent costs that must be incurred so that each addition of land area will reduce the income of traditional and intensive vaname shrimp farmers at the beginning of the vaname shrimp cultivation cycle period.

3.3. Technology

Based on the results of research in the field, aquaculture technology in the form of intensive and traditional aquaculture patterns provides results that are directly proportional to the income received by vaname shrimp farmers. Each addition of aquaculture technology will increase the income of vaname shrimp farmers, where the expansion of cultivation is in the form of improved management supported by modern tools so that each addition of vaname shrimp farming technology can increase the amount of vaname shrimp production and the desired size. The structured and well-managed intensive cultivation pattern allows vaname shrimp to grow optimally. Meanwhile, there is no management in the traditional vaname shrimp cultivation pattern, such as an irregular feeding schedule. The use of modern tools such as feeders, namely auto feeders, makes vaname shrimp get more feed evenly, while in traditional pond cultivation patterns, feeding is stocked by hand so that only sure vaname shrimp get more feed. Using a waterwheel in an intensive cultivation pattern makes the supply of oxygen to the shrimp so that a high stocking density can still make Vaname shrimp live in the pond.

Meanwhile, in the traditional cultivation pattern, oxygen is obtained naturally so that to keep the vaname shrimp alive, a low stocking density strategy is used. There is a laboratory with the right tools to identify pests and diseases on white vaname shrimp for immediate action in the intensive cultivation pattern, namely administering drugs or early harvesting. Whereas there is no disease detection device

in traditional system cultivation, so when vaname shrimp are exposed to pests, farmers immediately do early harvesting.

The process of industrialization of shrimp ponds based on information or interviews with the Environmental Service of existing shrimp ponds is by the Environmental Impact Analysis. Initially, the shrimp farming industry has existed since 20 years ago. The permit for the industrialization of shrimp ponds already has a license from the Integrated Licensing Service Agency, even though it has a key. Still, the existence of the shrimp pond industry is very closed. It was proven when researchers observed the shrimp pond industry, and researchers were not allowed to enter by security into the shrimp pond location. Even though they have obtained permission from the village head. In implementing the industrialization of shrimp ponds to the community, only a handful of people work in these ponds. The impact of automation is that there is environmental pollution on the environment.

4. Conclusion

Based on the research results, intensive and traditional vaname shrimp farmers can increase their income by increasing aquaculture technology, namely the conventional to semi-intensive and the intensive to super-intensive. Traditional and intensive system farmers can increase the revenue of the vannamei shrimp farming business by optimizing the significant value factors, namely the amount of production, labor costs, land area, and cultivation technology.

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