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Research paper



Carrying Capacity Atribute as Instrument of Sustainable Marginal Shrimp Pond Management at *Lowita* Minapolitan Estate, District of Pinrang

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Abstract

The period of pond shrimp and fish cultivation recovery potentially triggers cultivation area extention exceeding environmental carrying capacity and leads to massive harvest failure. The research was conducted in *Lowita* Minopolitan Estate, district of Pinrang, South Sulawesi province. The analysis of environmental carrying capacity was conducted through capacity of dissolved oxygen availability. These approaches result in different pond extentions based on technology levels; intensive, semi-intensive, and traditional. The daily volume of sea water available on the beach for the cultivation is 3,154,765 m^3 dy^{-1} in *Lotang Solo* village, 6,688,442 m^3 dy^{-1} in *Wiringtasi*, and 3,590,424 m^3 dy^{-1} in *Tasiwalie*. The waters environment carrying capacity is categorized as low at intensive cultivation pond. In case all pond areas are developed for traditional cultivation in *Tasiwalie*, *Wiringtasi*, and *Lotang Salo* with optimum production of 250 kg ha^{-1} CS^{-1}, the allowed pond area that does not exceed the carrying capacity will successively be 1,966.18 ha, 557.37 ha, and 157.73 ha.

Keywords: *carrying capacity, pond, shrimp, marginal, sustainable*

1. Introduction

Black tiger shrimp (Penaeus monodon) is still an important commodity in the effort to increase society's income and welfare in Indonesia. The practice of tiger shrimp cultivation disobeying the environmentally friendly cultivation principles, particularly in the shrimp booming era, has led to environmental degradation and extention of marginal ponds areas. Since 1998, the black tiger shrimp production has been collapsing because of environmental pollution and land degradation as the direct impact of uncontrolled employment of pesticide, chemical material, and drug.

District of Pinrang, South Sulawesi province, is one of Indonesia's black tiger shrimp production centres. Since 2007, the shrimp ponds in this district have recovered and resumed their production. The rise of tiger shrimp cultivation in Pinrang cannot be separated from the discovery and employment of phronima suppa (Phronima sp) (Fattah et al., 2014a). In 2014, the ponds spots in three villages in the district (Lotang Salo, Wiringtasi, and Tasiwalie) were determined as Lowita Minopolitan Estate. The increase of tiger shrimp production has the potential to trigger extention of cultivation areas and marginal areas. Marginal ponds are those that are no longer normally productive. Thus, the recovery and productivity increase aspects are the main reference in managing the marginal ponds areas. Since 1998, production of shrimp ponds at Lowita has been decreasing because of environmental degradation, poor managerial behavior, and pathogenic infection, particularly white spot syndrome virus (WSSV) and Vibrio harvey (Fattah et al., 2015).

Most of the marginal ponds are managed conventionally with poor management quality. The ponds in the estate are still managed traditionally through cultivation polyculture pattern. The ponds in Wiringrasi and Tasiwalie are directly impacted by Makassar Strait and Parepare Gulf which can be optimized to improve environmental carrying capacity for the ponds productivity. Improper pond management leads to insufficient water supply to support productivity (Fattah et al., 2014b). Water quantity available on the beach greatly determines water capacity to support development of pond cultivation, minimizes pollutant influence through cultivation waters, and creates an ideal environment for tiger shrimp and fish cultivated.

Carrying capacity deals with maximum quantity of fish that can be accommodated by a water body within a long period. Environmental carrying capacity system can decrease as the result of damage caused by people who keep decreasing energy supply (Charles, 2001). This research was to determine ponds extension with various technology levels that can be developed based on environmental carrying capacity attribute as reference to development of shrimp and fish sustainable cultivation at Lowita Minapolitan Estate, district of Pinrang.

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2. Method

2.1. Research Location

The research was conducted at uncared, marginal ponds in *Wiringtasi*, *Tasiwalie*, and *Lotangsalo*, subdistrict of Suppa, which have been determined to be *Lowita* Minapolitan Estate. It was undertaken for six months, from February to July, 2015. The data collected step was based on the season; (1) rainy season (February) and (2) dry season (July).

2.2. Data Collecting

The collecting data station was divided into three locations which were taken randomly. The locations were; (1) three stations of cultuvation representing the pond area that was planned for the pond extension, (2) three stations in coastal waters which represented the water source of the pond, and (3) three stations of aqeduct as the water source infrastructure of the pond; those were sluice duct, primer duct and secunder duct.

The observation and the data collecting were conducted during the tidal period. In every observation location of the sampling spot, the geogrphyc position was recorded by using GPS.

2.3. The Parameter of Water Quality

The observation of water quality was conducted to determine *the present status* of litoral condition related to the environmental properness for shrimp and fish in the pond. The observation was done once a month based on the the highest tidal and the lowest tidal that represented the rainy and dry season.

2.4. Data Analysis

The environmental carrying capacity for the pond cultivation extention was conducted through capacity of dissolved oxygen availability (SE, 2002; Meade, 1989; Boyd, 1990). The environmental carrying capacity of waters is based on the capacity of dissolved oxygen availability in water. This approach refers to the formula developed by Boyd (1990). This water succession is caused by tidal wave that will supply dissolved oxygen in water. To determine the dissolved oxygen availability in water is by recognizing the consentration of dissolved O_2 in *inflow* (O_{in}) and the minimum of expected concentration of dissolved O_2 from the cultivation system, which is 3 ppm (Boyd, 1990) in 24 hours. It needs 0,2 kg of O_2 per organic waste to lossen the organic material. The organic waste volume that can be accommodated without transcending the carrying capacity.

2.5. Result and Discussion

The research results encompass the parameter of water quality and the estimation of environmental carrying capacity for the cultivation.

2.6. Parameter of Water Quality

Generally, the quality of water in the observation area has not transcended the allowed constraint for the cultivation activity based on the criteria mentioned by Boyd (1990), Wedmeyer (1996). The parameter of water quality, based on the season, shows the difference between rainy season and dry season (Table 1).

Table 1: The avarege result water quality parameter in the pond, beach and aqueduct in rainy and dry season

Parameter	Rainy Season			Dry Season			Treshold
	Beach	Aqueduct	Pond	Beach	Aqueduct	Pond	
Salinity (ppt)	19.0	10.5	25.0	30.0	33.0	27.0	5 - 35
Temperature (°C)	*31.4	29.4	28.5	*32.4	27.2	29.5	21 – 31
DO (ppm)	7.8	7.5	6.2	7.9	7.8	8.2	≥ 3
pH	7.7	7.6	7.0	7.9	8	7.7	6.5 – 8.5
Posfat (ppm)	0.02	0.01	0.01	0.03	0.02	0.02	0.05 – 0.50
Ammoniac (ppm)	0.03	0.01	0.03	0.28	0.30	0.32	≤ 1
Nitrit (ppm)	0.10	0.02	0.01	0.10	0.02	0.10	≤ 0 – 0.25
BOD (ppm)	0.77	0.05	1.02	0.77	0.93	1.02	< 25

Annotation : *) has transcended the allowed constraint for the cultivation activity based on the criteria mentioned by Boyd (1990), Wedmeyyer (1996), Widigdo and Pariwono (2003)

The range of salinity during the rainy season is not far different from the range which is 10.5 – 19 ppt, while in dry season, it is about 27 – 35 ppt. Meanwhile, the pH proportion of water in the rainy and dry season is about 7 – 7.96, and it is still appropriate for shrimp cultivation.

The result of DO observation in rainy season is approximately 6.2 – 7.8 ppm and in dry season approximately 7.8 – 8.2 ppm which still accords for shrimp cultivation, the allowed DO constraint for shrimp and fish habitat. The highest dissolved oxygen in the afternoon at about 17.00 is 8.2 ppm in dry season and 7.8 in rainy season. The low of dissolved oxygen impacts on the biological function and growth. The oxygen solubility in water is influenced by temperature, salinity, organic material and the brightness (Boyd, 1990).

The ammoniac range during the rainy season is 0.01 – 0.03 ppm and 0.28 – 0.32 ppm during dry season. The nitrit concentration in the observation area during the rainy season is 0.01 – 0.10 ppm and 0.02 – 0.010 ppm during dry season. The main source of ammoniac is the material organic, either as food remains and shrimp dump or as plankton and suspended organic material. The level of ammoniac for shrimp growth is < 0.3ppm (Hardjowigeno and Widiatmaka, 2011).

The water volume for the pond should be sufficient to replace the pond water when needed. The pond area that can be flushed with sea water available on the beach for the cultivation extention of shrimp and fish with the 70 cm dy^{-1} of water level is 450,685 ha in *Lotang Salo*, 955.49 ha in *Wiringtasi*, and 512.91 ha in *Tasiwalie*. Meanwhile, with one meter of water level, the pond area that can be flushed is 315.47 ha in *Lotang Salo*, 668.84 ha in *Wiringtasi*, and 359.04 ha in *Tasiwalie*.

2.7. The Estimation of Enviromental Carrying Capacity for Cultivation

The determinant of waters carrying capacity based on the dissolved oxygen in water is figured by modifying the formula stated by Boyd (1990). The result of the research conduted by Widigdo and Pariwono (2003) and Wedemeyer (1996) concludes that the minimum level of oxygen for cultivation is 3 mg lt^{-1} (O_{out}). The observation conducted for 24 hours results that the dissolved oxygen data on the beach (O_{in}) is 5.1 mg lt^{-1} in *Lotang Salo*, 6.6 mg lt^{-1} in *Wiringtasi* and 5.3 mg lt^{-1} *Tasiwalie*.

Based on the observation result, the deviation between dissolved oxygen inside (O_{in}) and outside (O_{out}) the beach can be figured, 2.1 mg lt^{-1} in *Lotang Salo*, 3.5 mg lt^{-1} in *Wiringtasi* and 2.3 mg lt^{-1} in *Tasiwalie*. In regard to the assumption that the average of daily water volume avalaible (V_t) in *Lotang Salo* is 3,154,765 m^3 dy^{-1}, the avalaible oxygen capacity in waters should be 6,625.07 kg O_2. In *Wiringtasi*, the average of water volume avalaible is 6,688,442 m3 dy^{-1}, so the avalaible oxygen capacity in waters is 23,409.55 kg O_2. And the average of water volume avalaible in *Tasiwalie* is 3,590,424 m^3 dy^{-1}, so the avalaible oxygen capacity in waters is 82,579 kg O_2. According to Meade (1998), to decompose 1 kg of organic waste food, it needs 0,2 kg of oxygen so that the waters carrying capacity in *Lotang Salo* in decomposing waste organic is 33,125.35 kg, 117.047,7 kg in *Wiringtasi* and 412,898.8 kg in *Tasiwalie*.

Regarding with the result of research conducted by Boer's research in the cultivation in 2001 with 5,400 m^3 of area, 3 heads m^{-2} of stocking density and 130 days of cultivation can yield about 378 kg. This research results become the basic determinant in determining the environmental carrying capacity for cultivation in Minapolitan Estate of *Lowita* (Table 2, 3, and 4).

Table 2: Shrimp cultivation based on the technology levels in Lotang Salo

Parameter	Technology Level of Cultuvation[1)]		
	Intensive	Semi-intensive	Traditional Plus
Area (m^2)	10,000	10,000	10,000
Stocking Density (head m^{-2})	30	20	3
Cultuvation Period (day)	120	124	130
Food Volume (kg)	-	1.000	600
Sustainable Habitat (%)	45	40	81
Production (kg)	-	763. 31	250
Food Conversion Rate (FCR)	1.77	1.31	-
Pond Water Succesion (month)	5% (1), 10% (2.3) 15% (4)	3.3% (1), 5%(2), 10% (3 and 4)	Tidal Wave

Source : [1)] Boer, 2001

Table 3: Shrimp cultivation based on the technology levels in Wiringtasi

Parameter	Technology Level of Cultuvation[1)]		
	Intensive	Semi-intensive	Traditional Plus
Area (m^2)	10,000	10,000	10,000
Stocking Density (head m^{-2})	30	20	3
Cultuvation Period (day)	120	124	130
Food Volume (kg)	-	1.000	600
Sustainable Habitat (%)	45	40	81
Production (kg)	1,220.33	812.97	250
Food Conversion Rate (FCR)	1.77	1.31	-
Pond Water Succesion (month)	5% (1), 10% (2.3) 15% (4)	3,3% (1), 5% (2), 10% (3 and 4)	Tidal Wave

Source : Boer, 2001

If all pond areas are developed for traditional cultivation in *Tasiwalie*, *Wiringtasi*, and *Lotang Salo* with optimum production of 250 kg ha^{-1} CS^{-1}, the allowed pond area that does not exceed the carrying capacity will successively be 1,966.18 ha, 557.37 ha, and 157.73 ha.

Table 4: Shrimp cultivation based on the technology levels in Tasiwalie

Parameter	Technology Level of Cultuvation[1)]		
	Intensive	Semi-intensive	Traditional Plus[2]
Area (m^2)	10,000	10,000	10,000
Stocking Density (head m^{-2})	30	20	3
Cultuvation Period (day)	120	124	130
Food Volume (kg)	-	1.000	600
Sustainable Habitat (%)	45	40	81
Production (kg)	1,228.13	862.59	250
Food Conversion Rate (FCR)	1.77	1.31	-
Pond Water Succesion (month)	5% (1), 10% (2.3) 15% (4)	3.3% (1), 5% (2), 10% (3 and 4)	Tidal Wave

Source : [1)] Boer, 2001

4. Conclusion

The daily volume of sea water available on the beach for cultivation in *Lotang Salo* is 3,154,795 m^3 dy^{-1}, 6,688,442 m^3 dy^{-1} in *Wiringtasi* and 3.590.424 m^3 dy^{-1} in *Tasiwalie*. The waters carrying capacity in decomposing the waste organic in *Lotang Salo* is 33125.35 kg, 117,047.7 kg in *Wiringtasi* and 412,898.8 kg in *Tasiwalie*. The pond area that can be flushed from the beach for shrimp cultuvation with 70 cm ha^{-1} of sea water volume, which is mostly applied for traditional pond with water avalaibility on the beach, is 450,685 ha in *Lotang Salo*, 955.49 ha in *Wiringtasi*, 512.91 ha in *Tasiwalie*. Meanwhile, for 1m of water volume, semi-intensive and intensive pond utilization with water avalaibility on the beach is 315.47 ha in *Lotang Salo*, 668.84 ha in *Wiringtasi*, and 359.04 ha in *Tasiwalie*.

The waters carrying capacity is categorized as low for the intensive cultivation development. It can only support ponds in *Tasiwalie* which are totally 517. 41 ha with optimum shrimp production of 1.29 ton CS^{-1}. Meanwhile, in *Wiringtasi* the ponds are 154.82 ha with optimum shrimp production of 1.22 ton CS^{-1}. In order to keep the the preservation of beach environment, the volume of waste organic discarded to the waters cannot be in excess of 756 kg in *Wiringtasi* and 798 kg in *Tasiwalie*.

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