Carrying Capacity Analysis of Area of Sustainable Shrimp Cultivation Based on Land Suitability and Water Availability in Coastal Bay of Banten Indonesia

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ABSTRACT

Shrimp cultivation in the area that does not conform to the land suitability and natural resources potential, will affect the sustainability of production and profits. This research aims to assess the support capability of fishpond area of shrimp cultivation in the Coastal Bay Banten. The research location was in the fishpond area of Coastal Bay, Banten. Data analysis was conducted on primary data taken through field survey and secondary data obtained from the study of literature and reports. Research method of this study used two analysis approaches, namely: the weighting method of land suitability and ater supply method. the results of the analysis showed that subject to total land area of coastal bay Banten which is approximately 5028.3 hectares, there are three categories for shrimp cultivation, which are extensive or traditional, semi-intensive and intensive, with their areas consecutively are 4,460 ha, 746.91 ha and 166.43 ha. Shrimp Productivity per hectare in intensive cultivation system is the highest compare to the others two systems.

Keywords: intensive cultivation, semi-intensive, traditional, ater supply, land suitability

1. INTRODUCTION

The coastal bay Banten has a strategic role because it serves as an aquatic ecosystems buffer. Ecology pressure in this area is very high because several industries were established around this area, such as sugar processing industry (raw sugar), shipping industry, oil mining, thermal power generation, International Ports Bojonegara (Pelabuhan Internasional Bojonegara/PIB) and the dredging of sea sand sand causes coastal become pedestal, so that there is a contradiction among interests. Social conflict, economic interests, security and the environment may be rise degradation of natural resources that are directly caused a decline in the support capability, production and pollution increase. Shrimp production in 1992 could be up to 6,000 tons / year, in 2014 the results were 925.62 tonnes (Anonymous 2015). Indicators of environmental capability support of coastal area which are tendency of production development trend and land area (Prasita et al., 2008).

Results of research by Supendi et al. (2014), the production of traditional ponds in villages affected by river water area pollution Cibanten showed a decrease of 86-92%, while pond production that are affected by water river area pollution Ciujung fall equal to 77-78%. It is likely caused by degradation of environmental quality and utilization of land that does not conform to the support capacity. There are several constraints happen because aquaculture is an activity that has a socio-ecological systems, complex interactions between ecosystems, but produce a bright economic future (Schmitt, Brugere, 2013). Factors affecting support capability in shrimp ponds cultivation is arrangement of area or space of cultivation development (Suparjo, 2008). Cultivation practices that does not pay attention to sustainability and support capability can trigger the failure of cultivation (Ahmad 2006). Based on the description above, the purpose of this research was to assess the support capability of pond area of shrimp cultivation in Coastal bay Banten.

2. **Reseach Method**

2.1 **Location and time of the research**

Research area was in the pond shrimp in village in Banten with its coordinates of 05 ° 57'13″ 106 ° 6'6″ BT until Ciujung river, village Tengkurak at coordinates of 05 ° 57'48″ LS 106 ° 21'26″ BT. The field research was conducted in March-November, 2015.

2.2 Materials and Method

Support capacity analysis is required to determine the ability of pond production in a sustainable manner. Support capability shows the amount of environment's ability to support animal life that is expressed in the number of animal per unit area (Soemarwoto 1994). Research method in previous support capacity includes regression analysis methods, weighting and suitability of land and quantity of water supply (Prasita et al., 2008). Meanwhile, Sutrisno and Ambarwulan (2003) states that there are three methods, namely the method of weighting (weighting), assessment (scoring) and the dilution method (nutrient loading), Mustafa (2008) uses weighting. Furthermore, he assess the support capability by using evaluation of land suitability and method of spatial analysis and geographic information systems (GIS) (Store, Kangas 2001). Research on the support capability had been conducted by Rustam (2005) by using the method of measuring parameters of dissolved oxygen (DO) for the process of decomposition of organic waste and water assimilation capacity (the ability of water to accept the waste without causing polluted waters) with the result of the intensive, semi-intensive and extensive ponds. Meanwhile, Sitorus (2005) used the method of estimation of the environmental support capability based on the rate of biodegradation of waste ponds in the waters that divide the intensive, semi-intensive and extensive or traditional ponds area. This research uses method of water supply in the sea area of ponds area and land suitability with the method of weighting.

Availability of seawater for shrimp cultivation are calculated using method of field establishment. Meanwhile, land suitability uses parameter variable of water quality, soil quality, and supporting. The materials used for this research are sample of water and land in the coast bay of Banten, which are 24 points spread in ponds in coastal bay Banten. Water quality parameters measured are temperature, salinity, pH, dissolved oxygen (DO), BOD_5, COD, TSS, ammonia, Fe, tide. Soil quality parameters consist of pH, KCL and CEC, redox, nutrient consisting of Mg, Ca, K, soil texture, Fe, slope and elevation. Meanwhile, supporting consist of infrastructure comprising of roads and electricity, distance from the river, the distance from the beach and the annual rainfall. Materials used are test kits, laboratory instruments and measuring beams to measure tidal. Total variable of 25 parameters are processed with a score and weighting. The results of calculations made by overlaying maps (over lay) to determine intensive, semi-intensive and extensive ponds.

3. **Land Suitability with Weighting Method (Weighting).**

As a basis for determining the support capability of the weighting method has close dependability on suitability of qualitative land that next, it made to be quantitative. Rate of environment support capability is a quantification of land suitability classes. The results are shown by the intensive, semi-intensive and extensive ponds. The first step to calculate support capability is weighting of each parameter, then it is compared to ponds criteria that is appropriate to support capacity (Suparjo 2008).

3.1 Finding and Discussion

The determination of suitability level uses scoring method or weight liner combination. Weighting of each parameter is used for pair comparisons using a scale of 1 9 (Saaty 1977) with assessment criteria as shown in table 1 below. Weighting is done through discussions with experts and literature.

Table 1. Criteria of Location Evaluation

Score	Evaluation criteria	Description of Location
2,333 – 3,000	Intensive	This area has a parameter that is suitable with the researcher expectation in selecting the location of shrimp cultivation. Water supply, land and environment do not significantly affect the maintenance level of shrimp in ponds.
1,667 – 2,333	Semi Intensive	This area has parameter that already has a barrier in its utilization as shrimp cultivation. It has already required special input to be used as shrimp cultivation land.
1,000 – 1,667	Extensive	This area has barrier or parameters of water, soil and environments that require very highly input to be used as shrimp cultivation. The development is not possible on the scale that currently develops.

Measurements were made at 24 locations with the recapitulation as shown in table 2 below.

Table 2. Results of water quality parameter measurements

No.	Parameter	Measurement Result
1	Water temperature (°C)	25 – 34
2	pH	6,5 – 8
3	Salinity	4 – 43
4	Dissolved Oxygen	3 – 4,3
5	BOD5	6,4 – 70,07
6	COD	16,2 – 92,3
7	TSS	40 – 82
8	Amonia	0 – 2,5
9	Water color	coklat keruh hijau kekuningan
10	Water brightness	13 – 45
11	Water level	10 – 100
12	Fe	0 – 5
13	Tide (m)	1,1

The measurement result of parameter of water, land, and supporting quality in the field and laboratory are tabulated in matrix and then they are compared to the parameter standard of water, land, and supporting quality that are made based on study of literature and experts opinions. Field data of parameter of water, land, and supporting quality affecting shrimp cultivation is conducted the weighting and scoring based on land suitability. The multiplication result of this weighting and scoring is the total score.

Weighting is based on a *pairwise comparisons* matrix. Land suitability based on spatial technology is based on a hierarchical model implemented using software. Arc GIS 9.3 program is used for analysis material by interpolation of the soil data contained at a depth of 0 to 0.2 m. The total value of the table is integrated with land suitability criteria so that it will acquire land suitability class corresponding to the technology. The application of technology: (a) traditional (extensive), (b) middle (semi-intensive), and (c) advanced (intensive) (Decree of the Minister of Marine and Fisheries Number: KEP. 28 / MEN / 2004). The results of overlaying of water quality parameters as in Table 3, below.

Table 3. The land area based on the quality of water

Criteria	**Instensive**		**Semi Intensive**		**Exstensive**		**Total Area**	
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Ha**	**%**
Temperature	2.564,2	51,0	2.098,2	41,7	366,0	7,3	5.028.,	100,0
Salinity	1.146,0	22,8	3.469,9	69,0	412,5	8,2	5.028,3	100,0
COD	1.606,0	31,9	2.713,6	54,0	708,8	14,1	5.028,3	100,0
TSS	5.015,0	99,7	-	-	13,3	0,3	5.028,3	100,0
pH	545,6	10,9	4.482,7	89,1	-	-	5.028,3	100,0
DO	-	-	4.899,5	97,4	128,8	2,6	5.028,3	100,0
Ammonia	2.240,0	44,5	883,2	17,6	1,.05,2	37,9	5.028,3	100,0
BOD5	2.840,7	56,5	2.033,4	40,4	154,2	3,1	5.028,3	100,0
Fe	3.674,3	73,1	1.087,7	21,6	266,3	5,3	5.028,3	100,0
Tidal	-	-	-	-	5.028,3	100,0	5.028,3	100,0

Parameter of ground quality

The results of ground quality measurement is as in table tabel 4.

Table 4. Recapitulation of estimation amount of soil quality parameter measurement results

No.	Parameter	Results of Measurement
1	pH (H2O)	5,5 – 8,2
2	pH (KCL)	4,8 – 7,6
3	Texture of soiltanah	dusty clay, clay, sandy clay loam, clayey loam
4	Potential redox (mV)	112 – 240
5	KTK	7,49 – 29,85
6	K (ppm)	0,12 – 0,54
7	Ca (ppm)	0,15 – 0,54
8	Mg (ppm)	0,21 – 0,65
9	Fe (ppm)	1,64 – 5,51
10	Ni (ppm)	ttd – 0,31
11	Slope of land (%)	0,07 – 0,33
12	Elevation (m)	0,5 – 1,1

The result of overlaying soil quality parameters acquired land area suitable, and less appropriate as Table 5.

Table 5. Size of land based on soil quality

Criteria	**Intensive**		**Semi Intensive**		**Extensive**		**Total Area**	
	Area (ha)	**%**	**Area (ha)**	**%**	**area (ha)**	**%**	**Ha**	**%**
pH	1.955,3	38,9	2.558,6	50,9	514,4	10,2	5.028,3	100,0

Criteria	Intensive		Semi Intensive		Extensive		Total Area	
	Area (ha)	%	Area (ha)	%	area (ha)	%	Ha	%
Potential redox	5.028,3	100,0	-	-	-	-	5.028,3	100,0
KTK	561,3	11,2	3.091,8	61,5	1.375,2	27,3	5.028,3	100,0
Texture	977,2	19,4	4.051,1	80,6	-	-	5.028,3	100,0
Magnesium	-	-	4.788,2	95,2	240,1	4,8	5.028,3	100,0
Potassium	1.457,4	29,0	3.486,8	69,3	84,1	1,7	5.028,3	100,0
Calcium	-	-	-	-	5.028,3	100,0	5.028,3	100,0
Iron	-	-	-	-	5.028,3	100,0	5.028,3	100,0
Slope of land	5.028,3	100,0	-	-	-	-	5.028,3	100,0
Elevation	5.028,3	100,0	-	-	-	-	5.028,3	100,0

Aquaculture supports

Supporting aquaculture are variables that also must be taken into account for the cultivation of shrimp. The measurement results of contributing factors are as in Table 6 below.

Table 6. Summary of the results of measurements of supporting shrimp farming in ponds

No.	Parameter	Results of measurement
1	Distance from road (m)	61-2610
2	Distance from river (km)	20 – 900
3	Distance from river (m)	50 - 2000
4	Rainfall (mm)	621

The results from overlay resulting in the area of land based on supports such as in table 7 below.

Table 7. Area of land based on supports

Criteria	Intensive		Semi intensive		Ekstensive		Total Area	
	area (ha)	%	area (ha)	%	area (ha)	%	Ha	%
Distance from road	1.795,7	35,7	1.693,4	33,7	1.539,3	30,6	5.028,3	100,0
Distance from river	3.191,3	63,5	1.384,8	27,5	452,3	9,0	5.028,3	100,0
Distance from beach	994,8	19,8	3.817,4	75,9	216,2	4,3	5.028,3	100,0
Rainfall	-	-	-	-	5.028,3	100,0	5.028,3	100,0

Based on these three parameters then tabulated merging with the method of paired comparisons with niali score (S) and the weight, so obtain the results of conformity assessment such as table 8 below.

Table 8. Area of land based on water quality comparison, quality of ground and supports to shrimp cultivation in ponds

Criteria	Intensive		Semi Intensive		Extensive		Total Area	
	area (ha)	%	area (ha)	%	area (ha)	%	Ha	%
Water quality	655,1	13,0	4.351,0	86,5	22,2	0,4	5.028,3	100,0
Ground quality	4.358,9	86,7	669,4	13,3	-	-	5.028,3	100,0
Supports	1.994,2	39,7	2.697,1	53,6	337,0	6,7	5.028,3	100,0

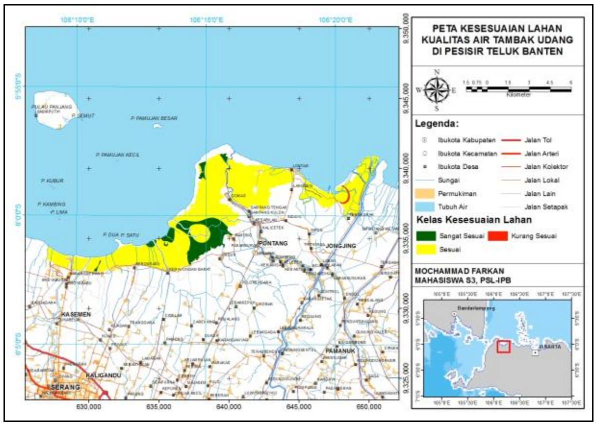
Land suitability in terms of the quality of water, soil and infrastructure with total area of 5028.3 ha with details such as table 9.

Table 9 Summary of the extent of land suitability classes for shrimp farming in the Gulf of Banten

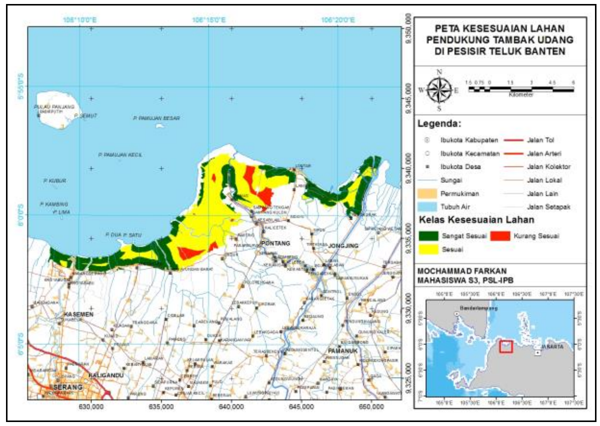
Criteria	Area	
	Ha	%
Intensive	141,7	2,8
Semi Intensive / Extensive	4.886.6	97,2

Extensive	-	-
Total	5.028,3	100.0

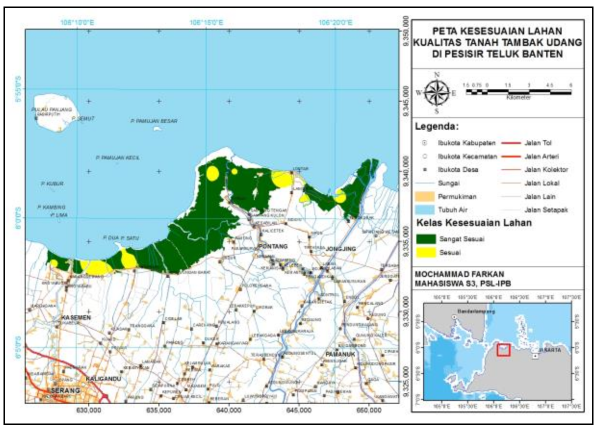
The data are implemented within the carrying capacity of the map based on the parameters can be seen in Figure 1.



(a)



(b)



(c)

Figure 1. Map of Land Suitability Application of Technology: (a) Parameter of Water Quality; (b) Supports Parameter and (c) Soil Quality Parameters

Based on the above map and data performed over lay that generatse maps of land based on three parameters such as in Figure 2 below.

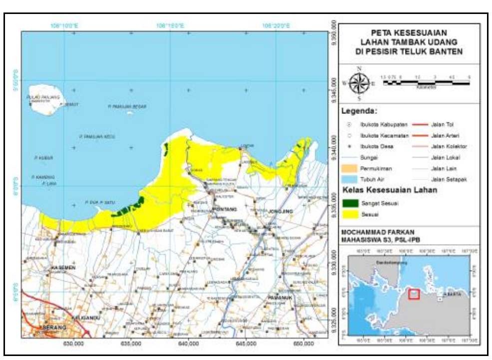


Figure 2. Map of Land Suitability Application of Technology intensive, semi-intensive and extensive in the area of ponds in the Gulf Coast of Banten

This result is similar to a research by Sitorus et al. (2005) that the carrying capacity by using sea water dilution and degradation capability of the waste in ponds Serang District at almost the same location is the intensive pond covering an area of 149.16 ha, or 2.88%, semi-intensive ponds 732.86 ha or 14, 1% and an extensive pond measuring 4.88,6 ha or 82.95%. The total area analyzed is 5174.44 ha . Based on the comparison of Sitorus (2005) and land suitability analysis obtained intensive land area of 141.7 ha (2.8%), semi-intensive and extensive 4.886.6 ha. When used for semi-intensive 14.1% and 82.95% extensive. Then the spacious of semi-intensive is 689,01 ha and extensive is 4.197.59 ha.

Calculating Carrying Capacity of Land with sea water availability

Supply of sea water is an essential element in shrimp farming in ponds because shrimp lives and grows in the water as well as breeding or water purification. For that water must be maintained in accordance with the quality and quantity of shrimp needs. This method refers to Prasita et al. (2008) ie the assumption of maximum production and availability of sea water. Also, studies that use methods with the availability of water (Widigdo, Pariwono Sitorus 2003 and 2005) although in practice this method is different.

In this research, the availability of seawater was measured using the method of field construction (Farkan, 2016). The method used is a development method which is the adjustment of the method developed by Widigdo and Pariwono (2003). The measurement technique is as follows.

1. To measure the height of the water then use bamboo that has been given a scale. While measuring the length then it used rope which has also been given a scale. This activity can be done by two or just one person.
2. In the early stages of determining the zero point (zero datum) on the beach. This position is a point on the coast which is a line of sea water at the lowest tide. The distance from the beach is measured using ropes with scale.
3. At the time of low tide then sought for droplets with a depth of 1 m and is not affected by seawater turbulence. In this water condition this is where the process of seawater purification before using them again for maintenance of shrimp in the pond.
4. The distance from the zero point is measured up to 1 m high point of the water using ropes.
5. Measurement towards a height point of 1 m should be perpendicular to the beach. So we use triangle with a formula of Pythagoras ie slashes quadrate number equals to the right angle. For that the long sides is 3: 4: 5. Installation of point was using bamboo and sides of the triangle was using ropes. Point A and B are parallel to the beach and point C is a point that leads to the zero point. The illustration on the beach is as figure 3.

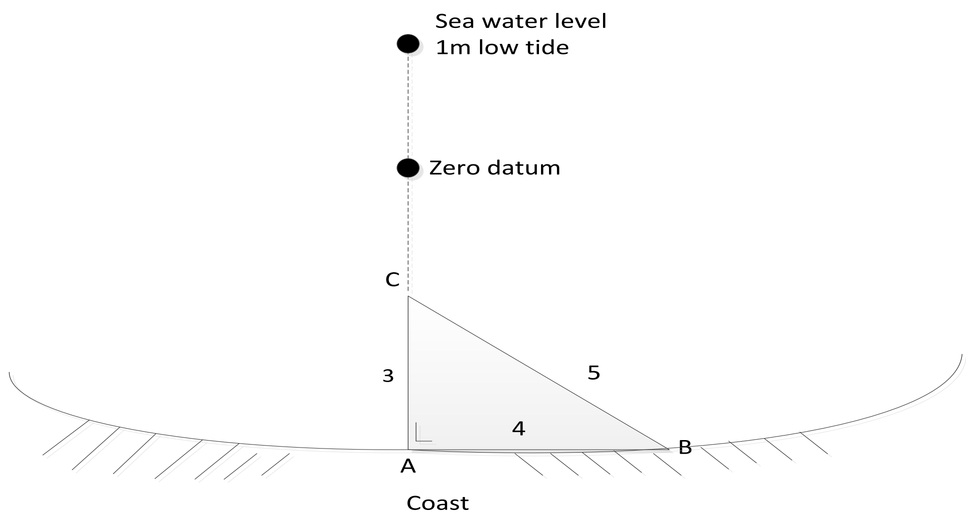


Figure 3. The straight line from the shore to the point of water height of 1 m at the time of lowest tide

6. Measure the distance from point zero to the point of water depth 1 m.

Illustration of size and field construction such as in Figure 4 below.

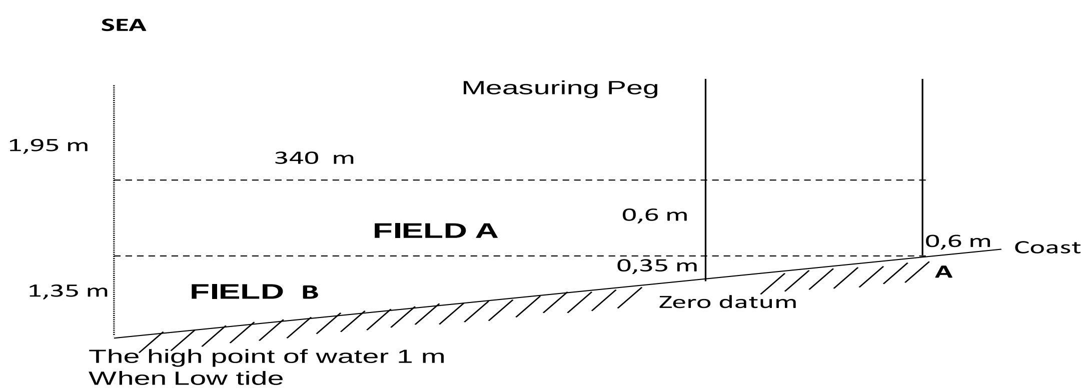


Figure 4. Field construction measurements at sea

Measuring cross section of field A

Field data such as in figure 3 and 4. Water height in zero point : 0,95. Water height at beach ,6. Length from the beach to the water height of 1 m of the lowest tide at the time of the lowest tide amounted to 340 m. Thus forming rectangle. Area of the rectangle is 0,6 x 340 m = 204 m^2.

Measuring cross section of field B.

Field B is triangular. For that the cross-sectional area B is 340 m x(0,5 x 1,35) = 0,675 x 340 = 229,5 m^2. Jadi total luas panampang rata – rata adalah 229,5 + 204 m2 = 433,5 m^2. The beach area of aquaculture coastal is 36.750 m. Volume of beach water available = 36.750 m x 433,5 m^2 = 15.931,12 m^3. Gulf of Banten experiences mixture tide lower so that the potential of the water volume 1.2 times tide. Thus the volume of of beach water = 1,2 x 20.065.500 m =

19.117,35 m³. The volume provides a measure of the volume of pond waste that can be supported at 19.117.35 m³ that also means the volume of sea water supply for cultivation in ponds is 19.117,35 m³. Based on Prasita *et al. (* 2008), then the intensive pond area that can be supported is 191.17 ha or amounting to 3,8 %.

Type of shrimp commodity cultivated in the coastal area of banten gulf is tiger shrimp and shrimp vaname. Production of intensive cultivation of tiger shrimp in one year 3 cycles is 12 ton/ha/year, vaname shrimp 24 ton/ha/year. Thus the average production is 36:2 = 18 ton/ha/year. Maximum production target is managed intensively in one season of farming is assumed to reach 18 ton/ha/year. If the maximum carrying capacity of water is 18 ton/ha x 191,17 ha = 3.441,06 ton /year. If the semi intensive technology with the capacity of production cultivation of semi intensive for tiger shrump three times of harvest is 5,1 ton/ha/year, vaname shrimp 12 ton/ha/year then the average production is 17,1:2 = 8,55 ton/ha/year. The comparison of intensive; semi intensive = 36 : 8,55 = 4,21. Thus the area of semi intensive ponds is 191,17 ha x 4,21 = 804,82 ha or 16 %. If managed extensively then the target of production is 853 kg/ha/MT, then the area of pond is 191,17 ha x (18.000 : 853) = 191,17 ha x (21,1) = 4.033,68 ha or 80,1 %. So the total of land is = 191,17 + 804,82 + 4.033,68 = 5.029,67 ha. The area of coastal ponds of Banten Gulf is 5.028,3 ha, then it can be mapped that the area of ponds with extensive technology is 4.033,68 ha; semi intensive 804,82 ha and intensive amounted to 300,98 ha or (3,8 %). This calculaiton is only relying on the number of seawater availability and has not count the organic materials by microbes and oxygen availability.

Traditional and extensive technology has sustainable influences than intensive, however the needs of food is becoming more demanding, thus the production can be increased and more sustained. One of the efforts in increasing carrying capacity is to increase the availability of water and the amount of bacteries eating waste so that it would comform with water quality for shrimp cultivation. A study of closed system technology performed by one of the institutions of education in Banten Gulf is able to produce shrimp amounted to 12 ton per cycle and one year is able to produce 3 times thus it is able to produce 36 ton /ha/year. This is system is done by not changing water everyday, and add water in the areas of ponds to change the missing water because of evaporation and leaking and shipon. To increase the carrying capacity there must consider policies, land organization, and rotation of commodity (Ahmad 2006), social (McDowell and Hess 2012), technology of aquaculture, human resources (Schmittou *et al.* 2004), ecology and social (Schmitt, Brugere 2013) and mangrove forest(Mishra *et al.* 2008).

Meanwhile, in other parts of carrying capacity increase can be done by combining traditional technology and modern, the implementation of better management, selection of good location, oriented on land and water carrying capatiy, effeciency of land use and water (Edwards 2015), strengthening technology, facilities and infrastructures (Sukadi, 2006), mangrove forest (Schmitt, Brugere 2013). Technology of cultivation obtains emphasis and in different technologies there are various effects towards environmental carrying capacity and capacity of produciton (Rasidi *et al.* 2013). As well as the management of land is determined based on land characteristics using technology and commodity that can be implemented in the ponds (Mustafa 2014).

2.8 Analysis of area productivity

Essential factors determining the completion of sustainable aquaculture is the selection of location that can be affected by the comformity of land and conflicts of water usage (Hossain *et al.* 2009). Referring to the discussion of production such as above, the intensive shrimp production 18 ton/ha/year, semi intensive 8,55 ton/ha/year and extensive 853 kg/ha/year. The results of water availablity analysis and comformity of land is not too differr, however seen from the average obtained an intensive area (141,7 + 191,17) : 2 = 166,43 ha 3,09 %, area of semi intensive = (689,01 ha + 804,82 ha):2 = 746,91 ha 13,9 % and traditional or extensive = (4.886,6 ha + 4.033,68 ha) : 2 = 4.460 ha 83 %. It is known the coastal pond area of banten gulf 5028,3 ha, thus the area of intensive pond 3,09 % x 5028,3 ha = 155,87ha, semi intensive 13,09 % x 5028,3 ha = 698,93ha, extensive 4.173,5ha

Based on this condition, then the productivity can be seen in table 10 below.

Table 10. Productivity of shrimp ponds in coastal area of Banten Gulf

Criteria	Area		Production	
	Ha	**%**	**Ton/Ha**	**Total /Ton**
Intensive	155,87	3,1	18	2.805,66
Semi intensive	698,93	13,9	8,55	5.975,85
Extensive	4.173,5	83	0,853	3.559,95
Total	5.028,3	100.0		12.341,46

Productivity above is only based on area, other factors have not been seen among other environmental, social, institutional and economic (Ting et al. 2015). Another factor is the increase in shrimp aquaculture management and policy management in land management (Sa *et al*. 2013).

In the area that is very appropriate, it is possible to develop intensive aquaculture that currently is only 60 ha, it is still far from intensive land availability. However, the reality on the ground in the area that was once used for intensive and semi-intensive cultivation based on existing conditions in the Gulf coast of Banten is 700 ha such as figure 4 below

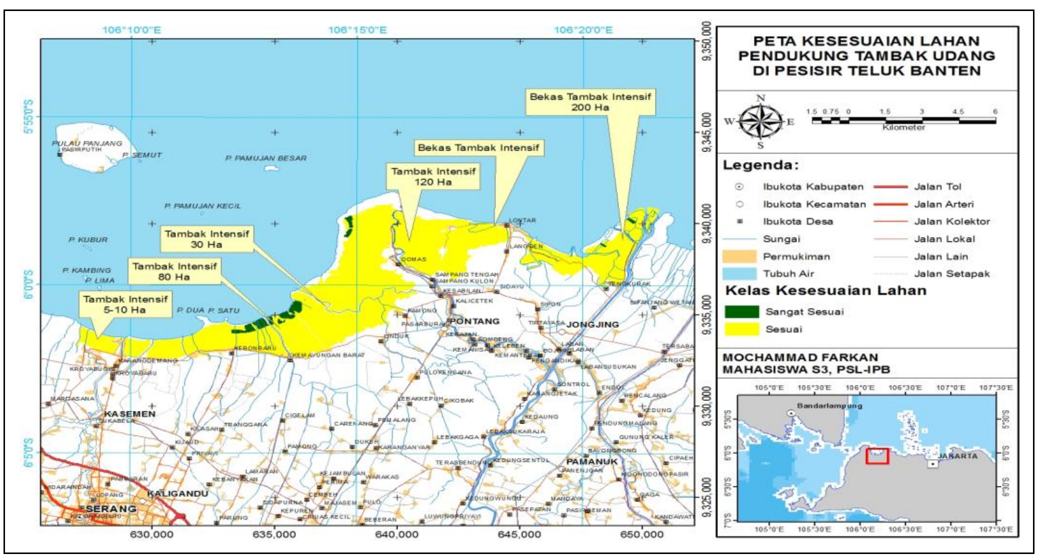


Figure 4. Map of ponds land intensitivity level in coastal area of Banten Gulf.

The analysis of carrying capacity are of pond intensive and semi intensive is 155,87 ha + 698,93 ha = 854,8 ha, thus for the developmend of natural condition may added to 854,8 – 700 ha = 154,8 ha. Production of shrimp in 2014 is 924,62 ton (anonymous 2015), potential of produciton is 12.341,46 ton. If managed sustainably by increasing the carrying capacity such as technology of environmental friendly, competent hman resources, facilities and infrastructures, regulation implementive and good teamwork and managed accordingly to the study and research then the production can be 11.416,84 ton/ year or amounting to 13,34 times.

CONCLUSION

The carrying capacity of the pond of the Gulf coast of Banten is covering 5.028.3 ha can be mapped to a traditional cultivation or extensive covering 4.173.5 ha (83%), semi-intensive 698.93 ha (13.9) and intensive 155.87 ha (3.1 %), the potential for shrimp aquaculture production amounted to 12.341.46 tons / year. Intensive aquaculture systems provide the highest yields compared to the other two systems, therefore, to increase the total production of necessary modernization of traditional production systems to intensive.

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