The relationship between shrimps production and mangrove ecosystem in Indramayu Regency

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Abstract. Shrimp is one of the agricultural commodities which has high economic value with global and increasing market value abroad. Thus, Shrimp production continues to increase. Shrimp production in Indramayu Regency in 2017 was 191,919.41 tons. This makes Indramayu Regency the largest producer of shrimp in West Java (BPS, 2017). Meanwhile, Mangrove is an area that has a high contribution. Mangrove ecosystems have an association with pond productivity. This study aims to analyze the productivity value of shrimp in Indramayu Regency and its effect on the mangrove ecosystem in Indramayu Regency in that particular area. The method that is used to change identify mangrove forests is Landsat 8 image then continued with composite band 564 and NDVI (Normalized Difference Vegetation Index) with a distance of 1 Km, 2 Km, and 3 Km from the mangroves. Furthermore, the result of the interviews is used to find out the value of shrimp productivity. Analysis of data is calculated through regression methods to see the relation proximity between shrimp productivity and mangroves. The regression result between the distance of mangroves and productivity yields with the value of R Square equals 71.7%. This result indicates a positive link between shrimp productivity and mangrove ecosystem.

1. Introduction
Coastal Region of Indonesia is an area that has abundant natural resource wealth with diverse population potential. Natural resources in the Coastal that can be managed include capture fisheries and aquaculture. The volume of national aquaculture production shows a positive trend in the last 5 years (2011-2015) with an annual average of 19.08% [1]. The exchange rate of fish cultivation business (NTUPi) in the period of 2014 - the first quarter of 2017 rose an average increase of 1.18%. In the first quarter of 2017, NTUPi reached 109.69%, which can estimate the number of fish farming businesses carried out by the community has a good level of business efficiency, earning a profit margin and the income gained increases [1].

On a macroeconomic scale, the International Trade Center data (2017) shows that from 2012 to 2016, the total value of national fishery commodity export s (HS 03) increased on average by 2% per year. In 2016 the total value of national fisheries commodity exports reached ± 2.9 billion US $, wherein with this value the aquaculture sub-sector dominated by giving a share of 60.03% of the total value of national fishery exports. Also, fisheries GDP based on current prices in the last 5 (five) years (2012-2016) shows an upward trend with an average increase of 14.6% per year and has a greater growth performance compared to other sectors.

Shrimp is one of the commodities of the fishery sector that is of high economic value with a broad and international market share that tends to increase. In the 1980s shrimp were once the fourth State foreign exchange supplier from the non-oil and gas sector after timber, textiles, and rubber. Producing
Shrimp through aquaculture for Indonesians is very profitable because the rupiah input can produce dollar output. Therefore, the Ministry of Maritime Affairs and Fisheries (KKP) has determined shrimp as one of the leading commodities. By making shrimp as a superior commodity, pond cultivation must be handled appropriately as a supplier of foreign exchange as well as the welfare of the pond farmers, but do not forget to pay attention to the surrounding ecosystem.

Shrimp production continues to increase. Shrimp production in Indramayu Regency in 2017 amounted to 191,919.41 tons. This makes Indramayu Regency the largest shrimp producer in West Java [2]. Appropriate land management can increase land productivity including cultivated land on ponds with the use of minimum input and does not cause environmental degradation. Pond management including land management is an important factor after determining the suitability of aquaculture land in a pond in the context of developing science and culture in a sustainable pond [3]. In general, ponds are usually found in swamp/mangrove areas because in these areas available natural resources can be utilized for aquaculture ponds.

Mangroves are a typical tropical coastal vegetation community, growing and developing in tidal areas, especially near estuaries, rivers, lagoons, and beaches that are protected with mud or sandy mud substrate. Mangrove ecosystems are a union of mangroves, animals and other organisms that interact with one another and their environment [4]. Mangroves are areas that have high productivity. In marine ecosystems, the production process can take place through the utilization of solar energy by autotrophic organisms, both micro and macro. With the help of sunlight, autotrophic organisms can convert inorganic materials into organic matter. The coastal area is a source of producing organic material in the marine ecosystem. Mangrove areas as shrimp nurseries have become one of the limiting factors for shrimp abundance in offshore waters [5].

2. Study site

2.1. Shrimp pond cultivation
Shrimp farming in ponds is a business activity of raising or enlarging shrimp starting from the size of the seed (fry) until it becomes a suitable size for consumption. Sea shrimp farming has been practiced in various countries in Asia, one of which is Indonesia. Shrimp commodities are generally classified as by products in ponds because they are used to pick up milkfish. Naturally, seedlings (shrimp seeds) enter the pond along with the tide that irrigates the pond waters. Shrimp production obtained in a single harvest is uncertain because it only depends on the amount and amount of shrimp seeds that are naturally present in the sea around the pond. The results are usually low, between 50-300 kg/year.

The development of shrimp commodity trade in the world market is getting better. The demand for shrimp has been growing so that the price of shrimp has become high. This fact makes pond farmers increasingly realize that shrimp production must be increased because it can be a greater profit opportunity than milkfish production. You do this by improving the shrimp culture techniques.

Production is an activity that converts input values into output. Usually, this activity is expressed in a production function which shows the maximum amount of output that can be generated from using several inputs using certain technologies. Production can be described as follows (Sugiarto et al, 2002).

2.2. Cost
The theory of short-run production costs, a characteristic of production, is the use of fixed inputs and variable inputs. Costs incurred for fixed input are called fixed costs (fixed costs) where these costs will not change even if the amount of output produced changes. Costs incurred for variable input are called variable costs (variable costs) where these costs will vary according to changes in output produced. The combination of fixed costs and variable costs is called the total cost [6].

Mangroves are areas that have high productivity. In marine ecosystems, the production process can take place through the utilization of solar energy by autotrophic organisms, both micro and macro. With the help of sunlight, autotrophic organisms can convert inorganic materials into organic matter. The coastal area is a source of producing organic material in the marine ecosystem. Mangrove areas as shrimp nurseries have become one of the limiting factors for shrimp abundance in offshore waters [5].
Coastal ecosystems, especially mangroves, can supply relatively large amounts of nutrients or inorganic material. This organic material comes from mangrove trees in the form of litter which can be decomposed into inorganic material. So that mangroves are one source of nutrition in marine organisms. Mangroves also play an important role in the life cycle of fish/shrimp as seen from their ecological functions.

3. Methods
Secondary data used in research such as those in Table 1. To manage mangrove vegetation data using aerial imagery/photographs with composite bands and NDVI. To identify mangrove vegetation using a combination of colors between RGB 564 on Landsat-8 (Figure 1). The color combination is included in the range of visible and near-infrared spectrum to sharpen the appearance of vegetation elements. The composite image will produce a pseudo color like the Table 1 [7].

![Figure 1. Spectrum color.](image)

For NDVI, use the equation from [8]:

\[
\text{NDVI Landsat 8} = \frac{(\text{Band 5} - \text{Band 4})}{(\text{Band 5} + \text{Band 4})}
\]

(1)

NDVI data processing is done with Envi 5.1 software and then processed using the math band tool. The NDVI results are deducted based on Indramayu Regency administrative boundaries with the Extract by Mask tool in ArcMap 10.4.1 software. Indramayu NDVI is then classified according to the Forestry Department using Reclassify in ArcMap 10.4.1 software.

| Table 1. NDVI mangrove density level [9]. |
|-----------------------------------------|
| Mangrove categories | NDVI value |
| Mangroves low | 0 < 0.33 |
| Mangroves mid | 0.34 < 0.42 |
| Mangroves high | 0.43 < 1.00 |

In this study, the method used to answer the problem formulation is spatial analysis, descriptive analysis, and simple linear regression analysis. Spatial analysis was carried out to determine the distribution of mangrove areas using composite bands, NDVI (Normalized Difference Vegetation Indonesia) and the distribution of shrimp pond areas located on the coast in Indramayu Regency. Descriptive analysis is used to explain and interpret the results of interviews with shrimp pond farmers around the study area. The analysis aims to answer the first formula. The next analysis is multiple linear regression analysis which aims to see a correlation between the independent variables and the most influential variables. This analysis is intended to answer the problem.
4. Result

Shrimp become the mainstay of production in the pond sector in Indonesia. There are 14 subdistricts in Indramayu Regency which cultivate shrimp as their main livelihood. These factors have caused Indramayu District to become the Regency with the largest shrimp producer in West Java Province to date. In Figure 2, it can be seen that shrimp productivity in Indramayu Regency has a graph that tends to increase every year starting from 2013 to 2017, but in 2018 there was a slight decline in both Vannamei and Windu Shrimp. Vannamei Shrimp have greater productivity than Windu Shrimp, it is known because Vannamei Shrimp can be managed through 3 systems namely Traditional System, Semi-Intensive System, and Intensive System.

Figure 2. Shrimp production line chart in Indramayu Regency in 2013-2018.

Whereas the Shrimp with the Windu type are only managed by the Traditional and Polyculture system so that the production is less than optimal. Shrimp aquaculture production in Indramayu has increased in 2017 by 60,000 tons in one year for Vannamei Shrimp and 34,000 tons in one year for the Shrimp of Tiger. This figure is quite large compared to other years. Shrimp Windu decreased in 2016 by 2,000 tons but the decline was not so large and could fit into a reasonable category.

There's a graph of Shrimp production over the past 5 years in the 5 Coastal Areas of Indramayu Regency. From this graph, it can be seen that there were some sub-districts which experienced a decline in production in 2015, namely Balongan District, Indramayu District, and Losarang District (Figure 3). It is different from Pasekan Subdistrict which every year experiences a fairly high increase and beats production in Cantigi District. In the Cantigi District, it tends not to change from year to year in 2013 reaching 18,000 tons of production and in 2018 reaching 17,739 tons, a decrease that is very visible in 2015 and 2016 which reached around 14,000 tons/year, the decline is known because pond farmers began to switch to milkfish and seaweed farming, they are farmers of fish farming using polyculture, that is, in one pond there are two species in it.

Figure 3. Shrimp production charts in 5 coastal districts Indramayu Regency in 2013-2018
Figure 4. Vannamei shrimp (left) and tiger shrimp (right).

Among the 5 subdistricts in this study, Balongan sub-district was the lowest in terms of production. This is because the pond area is not much so that production is not optimal, but it still shows an increase every year. It can be seen from the graph 4 that the increase occurred in 2017 and 2018 almost doubled from 2013 with achievements ranging from 6000 tons of Shrimp, both vannamei map based on the results of research conducted in the District of Balongan.

4.1. Productivity in Indramayu Regency

The selling price of shrimp in each district in Indramayu Regency there is differences (Table 2). The shrimp sales price is calculated for one year and multiplied by how much is harvested in one year. In general, ponds can be used 3 times a year, but in Indramayu Regency ponds can produce shrimp 3 to 4 times. Things like this will benefit the pond farmers but will reduce the environmental quality of the pond if done continuously.

| Categories | Balongan | Indramayu | Pasekan | Cantigi | Losarang |
|------------|----------|-----------|---------|---------|---------|
| Low        | 18,000,000 | 24,000,000 | 22,400,000 | 14,400,000 | 9,000,000 |
| Mid        | 36,000,000 | 42,000,000 | 48,000,000 | 42,000,000 | 42,000,000 |
|            | 42,000,000 | 36,000,000 | 31,500,000 | 28,000,000 | 36,000,000 |
|            | 48,000,000 | 48,000,000 | 30,000,000 | 24,000,000 |
|            | 32,000,000 | 36,000,000 |         |         |         |
| High       | 51,200,000 | 64,000,000 | 56,000,000 | 52,000,000 |
|            | 64,000,000 | 52,000,000 |      | 56,000,000 | 50,400,000 |
Table 3. Percentage of shrimp selling price (%).

| Categories | Balongan | Indramayu | Pasekan | Cantigi | Losarang | Total |
|------------|----------|-----------|---------|---------|----------|-------|
| Low        | 7        | 10        | 3       | 20      |          | 100   |
| Mid        | 13       | 7         | 13      | 10      | 10       | 53    |
| High       | 3        | 7         | 10      | 7       | 27       | 100   |

In Balongan District the smallest sales revenue was IDR 18,000,000, while in Indramayu District was IDR 14,000,000. The smallest sales results in Indramayu Regency are located in Losarang District. That is because in Losarang District the harvest is carried out twice a year, another thing is because the location is near the Jalan Rura Pantura (North Coast) so that it is difficult to get clean water supply. The highest sales were in Pasekan Subdistrict to touch the figure of IDR. 64,000,000 in one year per pound. Pasekan District has a high sales result of 10%, which is the highest compared to other districts. The average sales of shrimp in the Cantigi District reach IDR 50,000,000 annually.

Figure 5. Map of shrimp pond productivity.

Shrimp pond productivity in Indramayu Regency can be calculated with the production yield (kg) /area/year. So the unit of productivity in this study is kg/area/year. It can be seen in the table below, that the highest productivity is found in Cantigi and Pasekan Districts at 800 kg/area/year. While the lowest productivity was found in Losarang District of 180 kg/area/year.
Table 4. Shrimp pond productivity in one year (kg/area/year).

| Categories | Balongan | Indramayu | Pasekan | Cantigi | Losarang |
|------------|----------|-----------|---------|---------|----------|
| Low        | 270      | 300       | 300     | 280     | 240      |
|            | 280      | 640       | 600     | 600     | 600      |
|            | 600      | 400       | 450     | 360     | 450      |
|            | 600      | 450       | 600     | 600     |          |
|            | 400      | 480       | 450     | 10      |          |
| High       | 800      | 800       | 800     | 800     | 720      |

Table 5. Percentage of shrimp pond productivity (%).

| Categories | Balongan | Indramayu | Pasekan | Cantigi | Losarang | Total |
|------------|----------|-----------|---------|---------|----------|-------|
| Low        | 7        | 7         | 7       | 7       | 20       | 100   |
| Mid        | 13       | 13        | 13      | 10      | 7        | 57    |
| High       | 7        | 10        | 7       | 23      |          |       |

Based on the above calculation, it can be seen that the Districts that have low shrimp pond productivity are Balongan District, Indramayu District, and Losarang District. Moderate productivity is almost in all sub-districts, but the lowest is in Losarang sub-district by 7%. While the Districts that have High Productivity are Pasekan District, Cantigi District, and Losarang District. From these results, it can be seen that in the Pasekan and Kecamatan Sub-districts are good locations for shrimp farming as seen from the sales results and productivity results in one year show good numbers.

5. Conclusion
Shrimp productivity in Indramayu Regency tends to increase every year. The highest productivity was found in Cantigi and Pasekan sub-districts. In general, there was no drastic decrease in shrimp productivity from each subdistrict, but there was a change in the main centers of shrimp production from Cantigi District to Pasekan District. Cantigi and Losarang subdistricts have a high area of mangrove so that the productivity of shrimp ponds in the district is also high. Unlike the Districts that have a low mangrove area and density such as in Balongan and Indramayu Districts the productivity, results tend to below. Reinforced by regeneration calculations that produce positive correlations. Thus, the Mangrove Ecosystem can be said to affect shrimp productivity in Indramayu Regency, the better the mangrove ecosystem in a place, the higher the shrimp pond productivity will be.

6. Reference
[1] KKP 2018 Budidaya Udang Masih Sangat Potensial
[2] BPS 2018 Provinsi Jawa Barat Dalam Angka 2018 (Badan Pusat Statistik: Provinsi Jawa Barat)
[3] Karthik M, Suri J, Sahran N and Biradar R S 2005 Brackish Water Aquaculture Site Selection in Palghar Taluk, Thame district of Maharashtara, India, Using the Techniques of Remote
Sensing and Geographical Information System Aquacultural Engineering 32 285-302

[4] Minister of Forestry Regulation 2010 P 35

[5] Martosubroto, Purwito, Nurzali and Naamin 1977 Relationships between tidal forest (mangroves) and commercial shrimp production in Indonesia Marine Research in Indonesia 81-86

[6] Sugiarto, Herlambang T et al 2002 Ekonomi Mikro Sebuah Kajian Komprehensif (Indonesia: PT Gramedia Pustaka Utama)

[7] Purkis S and Klemas V 2011 Remote Sensing and Global Environmental Change Publishing Wiley-Backwell

[8] Pal S and Ziaul S 2017 Detection of land cover change and land surface temperature in english bazar urban centre The Egypt J. Remote Sens. Space Sci. 20 125-145

[9] Departemen Kehutanan 2006 Mangrove Density Level

[10] Tim Perikanan WWF-Indonesia and Badrudin 2014 Better Management Practice Seri Panduan Perikanan Skala Kecil Budidaya Udang Vannamei Tambak Semi Intensif dengan Instalasi Pengolahan Air Limbah (IPAL) (Indonesia: WWF-Indonesia)

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