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Analysis of Mathematical Models in Mapping Total Suspended Solids (TSS) on the Coast of Banyuwangi Beach Based on Satellite Image Data

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Abstract- Total suspended solids or TSS is a parameter that is widely taken as research material to know the quality of the bodies of water both locally and globally. To obtain an overview of the TSS concentrations along the coast, it requires a technology that can monitor very large areas, and one of the methods is remote sensing techniques with the utilization of satellite imagery. In this research, the developed method is a remote sensing method using Aqua Modis satellite imagery Level 2 with wavelengths used to compile mathematical models are 412 nm, 531 nm, and 667 nm. The result obtained from this study is 412 nm wavelength is the most optimum wavelength to map the concentration of TSS on the coast because at this wavelength the value of the R^2 correlation is the greatest among the other wavelengths, while the most suitable mathematical models are linear models and logarithmic models. The conclusion obtained from this research is the spread of TSS (mg/l) on the coast of Banyuwangi no one exceeds 100 mg/l at the coordinate point of data retrieval, TSS spread ranges in concentrations of 40 to 50 mg/L following the thematic maps shown.

Keywords- *Aqua MODIS, Total Suspended Solids, Coastline, Satellite Imagery Reflectance*

I. INTRODUCTION

Total suspended solids or TTS is one of the parameters that is often used as an indicator of water quality pollution. In the coastal area, the total suspended solids commonly referred to as TSS is particle grains brought by sea currents from other regions to a place and settle there. The precipitation process that occurs over a long period will lead to the buildup of solids in the area and will eventually cause sedimentation in the coastal areas [1], [2]. The sedimentation process takes years and will cause changes to geomorphology from the coastal coast as well as will also cause a change in coastline [3]–[6].

Measurements of the value of TSS concentration in coastal areas have been widely researched both manually at a certain point as well as globally with the utilization of technology that supports it. One technology that is widely used in today's era is remote sensing techniques by utilizing satellite imagery. This technique has been widely used for monitoring on a wide scale because satellite imagery has a huge coverage area so that morphological changes and coastal ecosystems can be monitored more accurately and efficiently.

The use of satellite imagery for mapping content and distribution of TSS in coastal areas is very popular among remote sensing experts, where the satellite imagery used varies with various advantages of its diverse image resolution. For mapping the TSS are using MERIS image [7], Aqua MODIS image [8], Terra MODIS [9][10], some are using the imagery of Landsat [11][12], [13], Image of SPOT [14], and satellite imagery of VIIRS [15]. The resulting photo Scene has a digital number that is characteristic for recording in certain areas and in the Sensory object. This characteristic trait that is often used as a determination in analyzing a change on the face of the earth is both land-use change and the change of ecosystem of coastal areas.

The purpose of this research is to map the concentration of TSS on the coastal coast in Banyuwangi which is located near the Strait of Bali and close to the area of Blambangan, besides, it is also wanted to look for a mathematical model for the most optimal concentration of TSS that bias describes the characteristic spread of TSS due to currents and waves caused by the movement of vessels from the port of Ketapang to the port Gilimanuk and vice versa.

II. MATERIAL AND METHODS

A. Satellite Imagery

The satellite imagery used in this research is the image of Aqua MODIS satellite which obtained from the website https://oceancolor.gsfc.nasa.gov/, where the process of acquisition of the image is January year 2020 with the file name A2020018060000. L2_LAC_OC. NC. Initial A shows that the file is a type of the MODIS Aqua satellite image while the next 4 digits are the year of Image acquisition of the year 2020.

B. TSS Measurements

Total suspended solids (TSS) measurements are done by retrieving the sample data on the surface of the sea along the Coast of Banyuwangi at the coordinates specified by the fishing boat combed along the coast by using a mineral water bottle tool that has a volume of 1.5 liters, the process of

retrieval is done by dipping the bottle in approximately 30 cm below the surface of the seawater and filled to, the bottle closes tightly and is numbered according to the existing coordinates. The collection took place at 10.00 to 12.00 times of West Indonesia (WIB) as much as 20 pickup points.

To obtain a TSS estimate, the difference between total suspended solids and total solids is calculated.

$$TSS\ (mg/L) = (A-B)\ X\ 1000 / V \quad (1)$$

With understanding:

A = weight of filter paper + dry residue (mg)
B = Weight of filter paper (MG)
V = Sample Volume (mL)

C. Formulation of Mathematical Modeling

The mathematical model will be compiled to find out which model will later provide the most optimal results that will be seen from the suitability of the model with the existing data through the observation of the existing R^2 value. The models that will be tested on this research are linear model, exponential, logarithmic and power model, which from the calculation of each model will also provide existing R^2 value so that later this R^2 value will determine which is the most optimum model that can describe the concentration of TSS value on the coast of Banyuwangi.

D. TSS Distribution Value Mapping

To perform the mapping of the TSS (Mg/l) value distribution of the SeaDAS 7.5 software, which with this software is an intrusive TSS distribution map using the most optimum mathematical model algorithm that has been obtained from the measurement of the model by involving the Refelktan data of the fashionable Aqua image and the field data of the TSS value.

III. Result And Discussion

The aqua modis image obtained and processed with the software SeaDAS version 7.5 with multiple stages, where the first stage performed is to cut the satellite imagery of the original following the desired area or area of interest (AOI). The results of the cutting of the satellite image can be seen in Figure 1.

It is seen in Fig. 1 that the location of the research to the area of Banyuwangi regency which is surrounded by the island of Bali, the Bali strait, and the South Coast. The coordinates are visible in figure 1 is still not corrected properly, so from such Images need to be processed again with the rearrangement of the projection is there, and the result of the process of restructuring (reprojection) can be seen in Fig 2.

In Fig. 2 the projection coordinate settings have been reset, therefore the display is perpendicular where the existing satellite imagery becomes tilted, and after this re-projection then the next stage determines the total data retrieval point suspended solid at the already measured point in the field with the help of GPS navigation, and the placement result of the data retrieval point can be seen in Fig. 3. Where in Fig. 3 is the magnification of Fig. 2 for the coastal area of Banyuwangi.

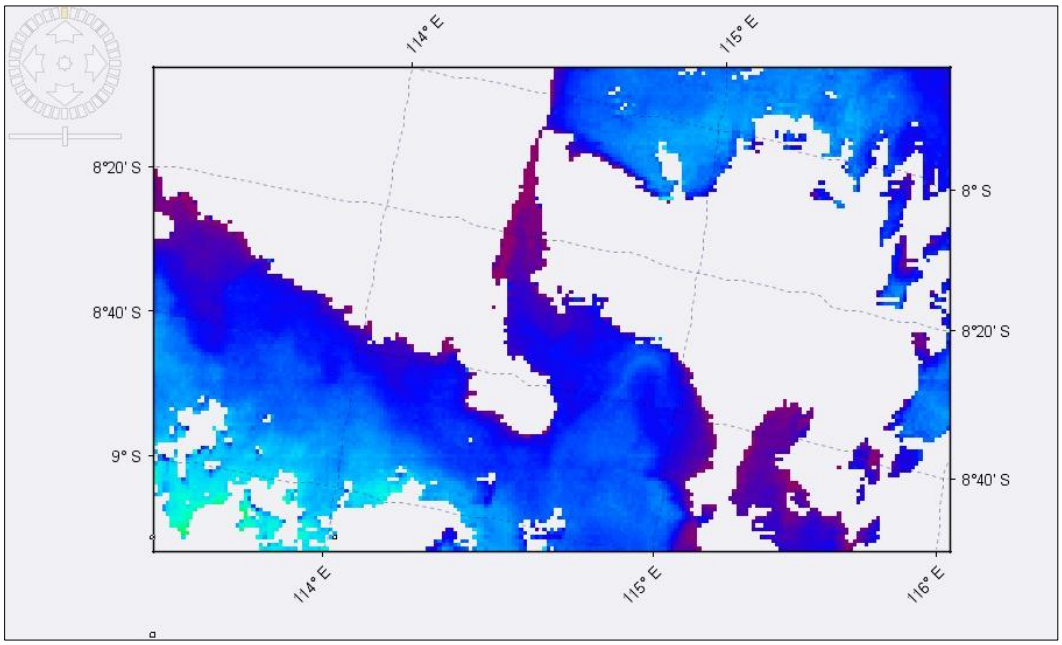

Figure 1. The look of the aqua modis satellite Image after the cut according to the AOI

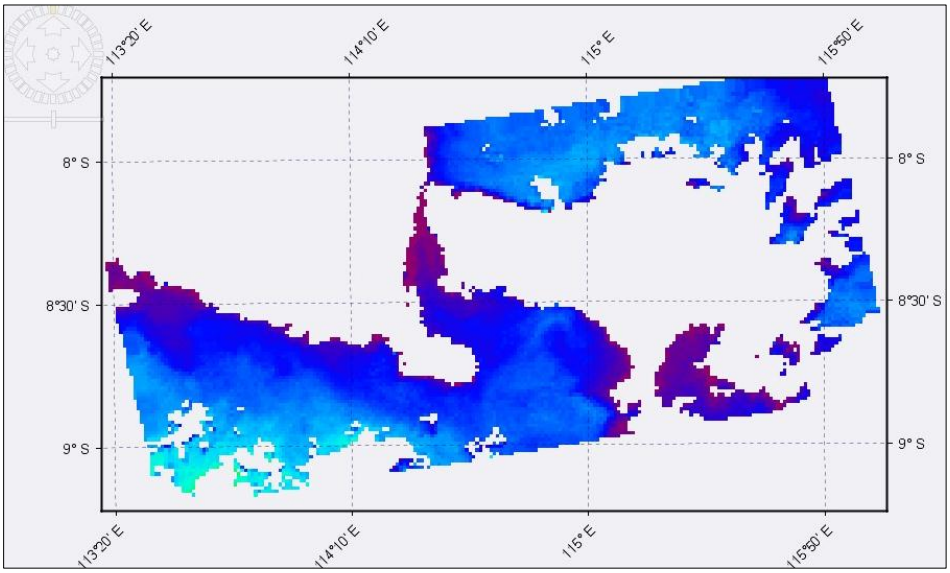

Figure 2. The aqua modis image after reprojection

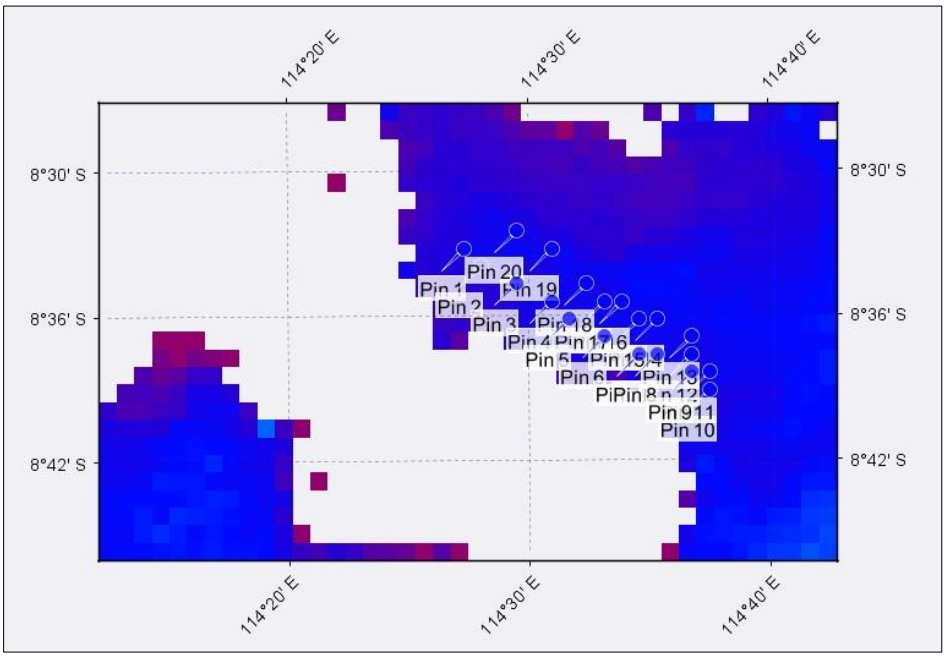

Figure 3. Coordinates the retrieval of data TSS

The results of the wavelength frequency of the Aqua Modis satellite imagery for the 412 nm channel are shown in Fig. 4, wherein the figure shows that the values at the 412 wavelengths are concentrated at 0.005 and 0.0075. The total frequency of this value will affect the distribution of TSS values in the coastal districts of Banyuwangi and the Bali Strait in general. As for the frequency at the wavelength of 531 nm shown in Fig. 5 and the wavelength of 667 nm shown in Fig. 6. Fig. 5 of the histogram displayed at wavelength 531 shows concentrated values at the numbers 0.001 and 0.003, this is different from what is shown in Fig. 6 where at a wavelength of 667 nm it is seen that the concentrated values are 0.00 and 0.001.

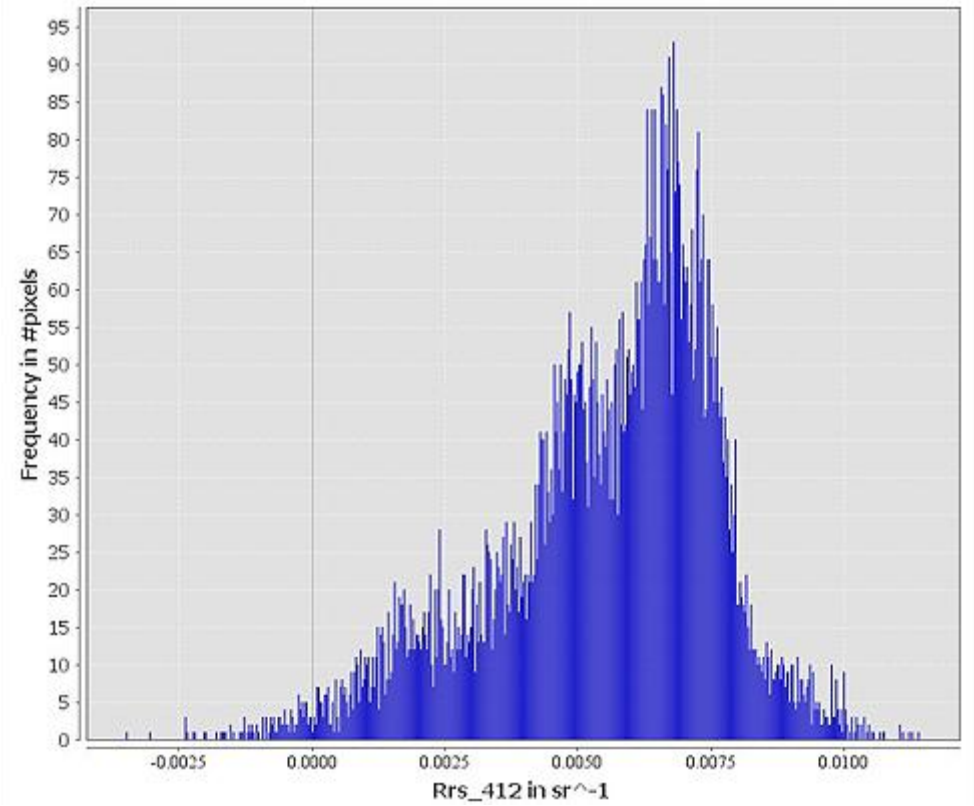

Figure 4. The aqua modis hisogram at a wavelength of 412 nm

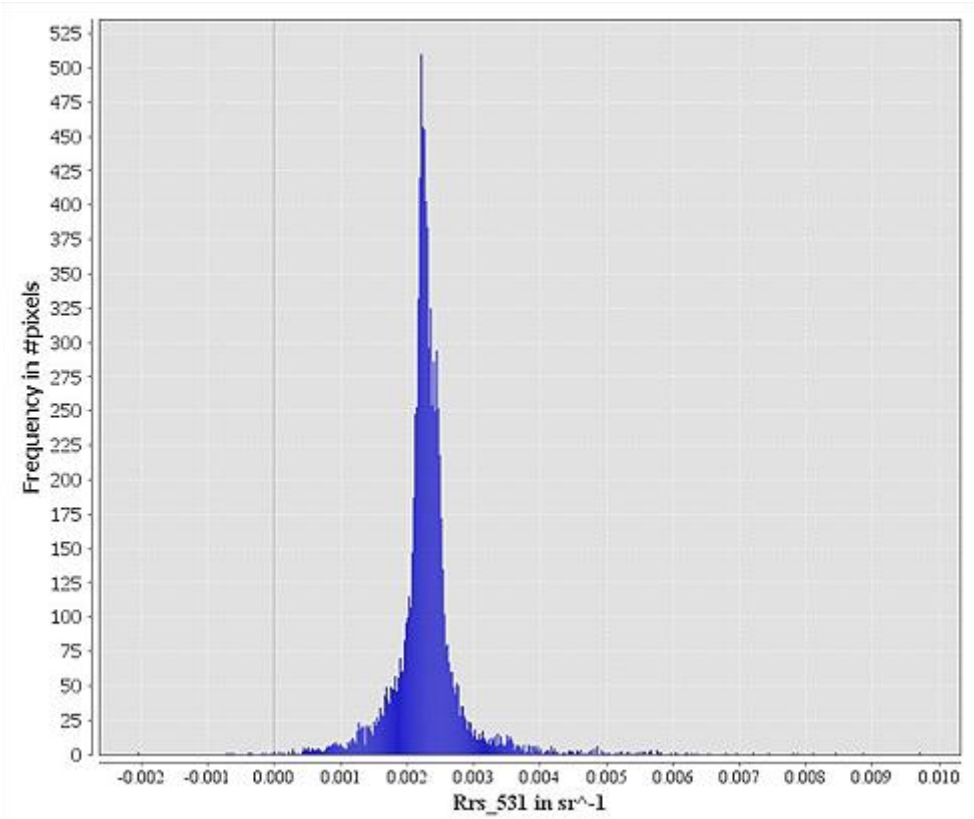

Figure 5. The aqua modis histogram at a wavelength of 531 nm

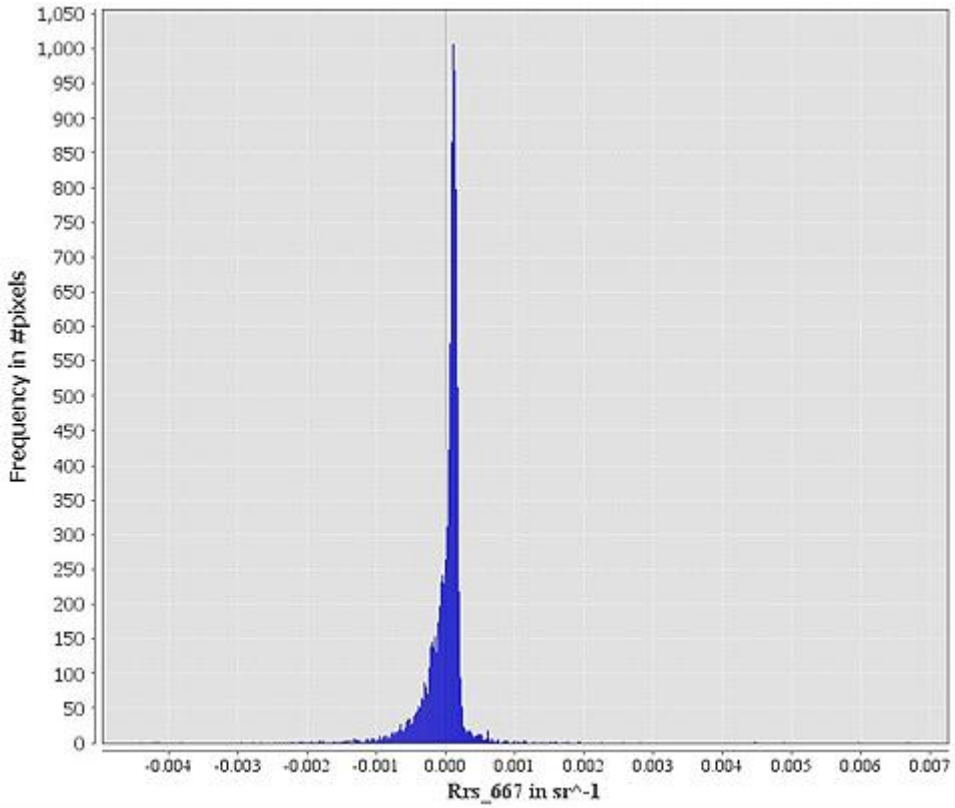

Figure 6. Aqua modis histogram at a wavelength of 667 nm

The results of TSS concentration measurements at predetermined coordinates are shown in Table 1 wherein the table there are 20 data sampling points, and from the 20 data, the first 15 data are taken to find the best mathematical model algorithm from the TSS concentration distribution using trend analysis of linear regression. The results of this calculation will be shown a mathematical equation model and also the correlation value R^2 which will determine the relationship between field data in the form of TSS concentrations with the reflection of Aqua Modis satellite imagery as an independent variable.

For the TSS values obtained, further processing is done using the trend regression analysis method using several mathematical models selected with reflectance values of satellite images and the results are shown in Table 2. In Table 2, it can be seen that from the four existing mathematical models, the linear model and the model logarithmic has the highest R^2 value among other models namely exponents and power, so the linear and logarithmic model is taken as the optimum model of the distribution of TSS values in the coastal waters of Banyuwangi district.

After knowing the most optimum model is linear and logarithmic, the last remaining data from the field data that is 5 data is performed validation calculations using the reflectance value of satellite images at 412 nm wavelength by entering this value into the mathematical equation of linear and logarithmic models, and the results of The calculation process is shown in Table 3.

TABLE I. TSS CONCENTRATION (MG/L) AT COORDINATE POINT

Data Point	Longitudinal	Latitude	TSS (mg/l)
1	114 26' 24,27"	-8 34' 07,04"	51,3
2	114 27' 07,96"	-8 34' 50,88"	52,9
3	114 28' 35,24"	-8 35' 35,05"	37,2
4	114 30' 02,52"	-8 36' 19,18"	33,1
5	114' 30' 46,01"	-8 37' 03,06"	35,4
6	114 32' 13,31"	-8 37' 47,19"	34,8
7	114 33' 40,61"	-8 38' 31,34"	64,7
8	114 34' 24,38"	-8 38' 31,62"	38,2
9	114 35' 51,70"	-8 39' 15,73"	34,7
10	114 36' 35,24"	-8 39' 59,60"	35,1
11	114 36' 35,50"	-8 39' 16,01"	32,6
12	114 35' 51,97"	-8 38' 32,17"	32,3
13	114 35' 52,26"	-8 37' 48,57"	32,7
14	114 34' 24,96"	-8 37' 04,46"	34,5
15	114 33' 41,15"	-8 37' 04,18"	35,8
16	114 32' 57,66"	-8 36' 20,31"	33,6
17	114 32' 13,87"	-8 36' 20,03"	35,1
18	114 31' 30,36"	-8 35' 36,19"	38,5
19	114 30' 03,38"	-8 34' 08,47"	36,1
20	114 28' 36,08"	-8 33' 24,31"	32,8

TABLE II. MATHEMATICAL MODEL AT 412 NM WAVELENGTH WITH CORRELATION R^2

No	Algorithm	Model	R^2
1	Linear	TSS (mg/l) = -15100x + 101,08	0,8261
2	Exponent	TSS (mg/l) = $148,11e^{-330,1x}$	0,8117
3	Logarithmic	TSS (mg/l) = -55,12ln(x) - 264,41	0,847
4	Power	TSS (mg/l) = $0,0524x^{-1,197}$	0,8214

Source: Calculation from trend analysis

TABLE III. VALIDATION TSS DATA WITH MATHEMATICAL MODEL LINEAR AND LOGARITHMIC AT 412 NM

TSS Insitu	TSS Linear	TSS Logarithmic
33,6	32,0126	32,5417
35,1	37,2674	36,9034
38,5	34,7608	34,7797
36,1	40,4384	39,7129
32,8	32,0126	32,5417

Table 3 shows for each TSS value for field data, the data from linear and logarithmic satellite imagery counts are not too different, but to be able to conclude scientifically it requires a statistical correlation analysis by comparing the three and finding which one has a stronger relationship with how to see the greatest value of the correlation data. The results of the correlation calculation are shown in Table 4.

TABLE IV. COMPARISON OF TSS INSITU WITH LINIER AND LOGARITMIC

TSS	In situ	Linear	Logaritmic
In situ	1		
Linear	0,488701	1	
Logarithmic	0,478826	0,999827	1

Fig. 7 shows a thematic map of the distribution of TSS concentrations (mg / l) at a wavelength of 412 nm for a linear mathematical model, in which the Banyuwangi coast near the Bali Strait has a range of values of 43.52 to 58.92 milligrams per liter. Whereas for the distribution of TSS in the histogram display as shown in Fig. 8 for the linear model algorithm, the concentration of TSS is obtained at a value of about 25 to 60 milligrams per liter.

IV. CONCLUSION

The distribution of TSS concentrations in the coast of Banyuwangi has a not too large interval where the interval value is 20 to 60 milligrams per liter and for the research point obtained the average TSS concentration is 45 mg / l so that it can be said that the condition of the waters in the Banyuwangi coast parallel to the coastline have the same phenomenon in the distribution of turbidity due to suspended solids at sea level. The condition of the waters in the Bali Strait also contributes to the accumulation of TSS concentrations in these waters.

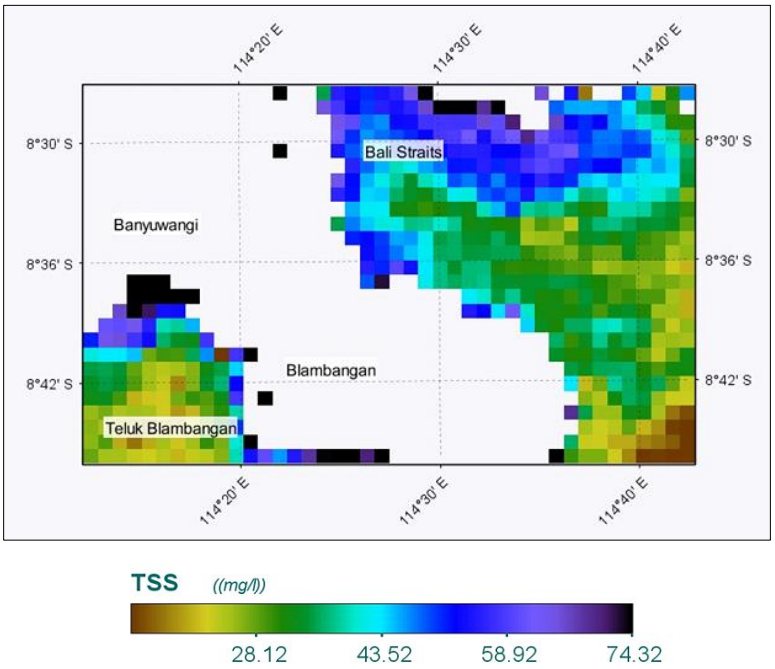

Figure 7. Thematic map of the distribution of TSS on the coast of Banyuwangi with a linear algorithm

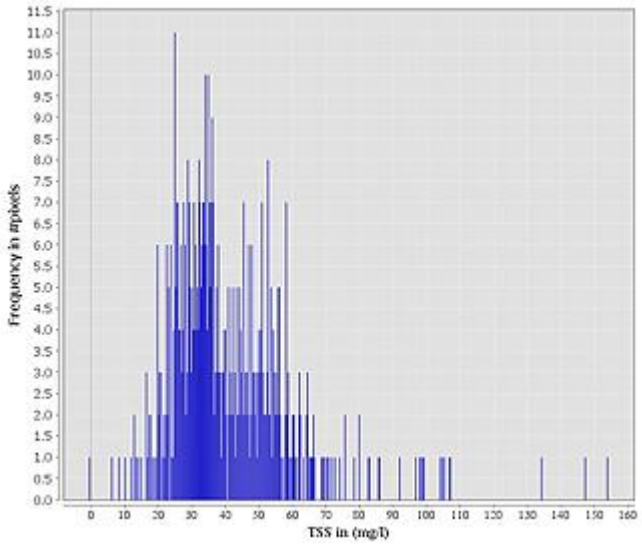

Figure 8. Histogram of TSS value distribution (mg/l) with linear algorith

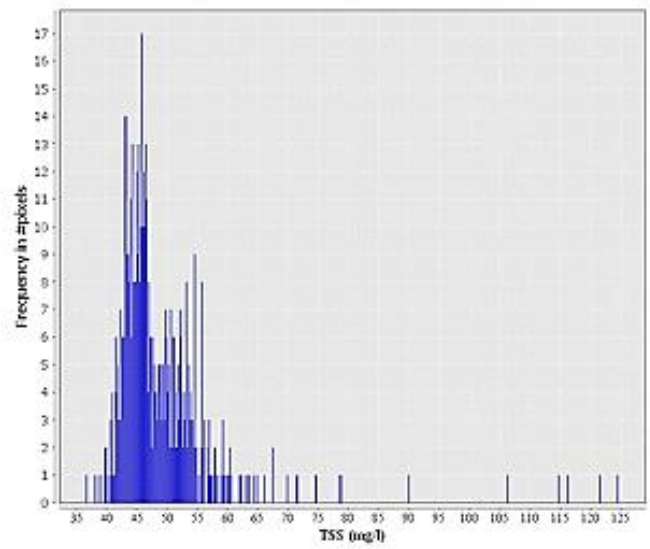

Figure 9. Histogram of TSS value distribution (mg/l) with logarithmic algorithm

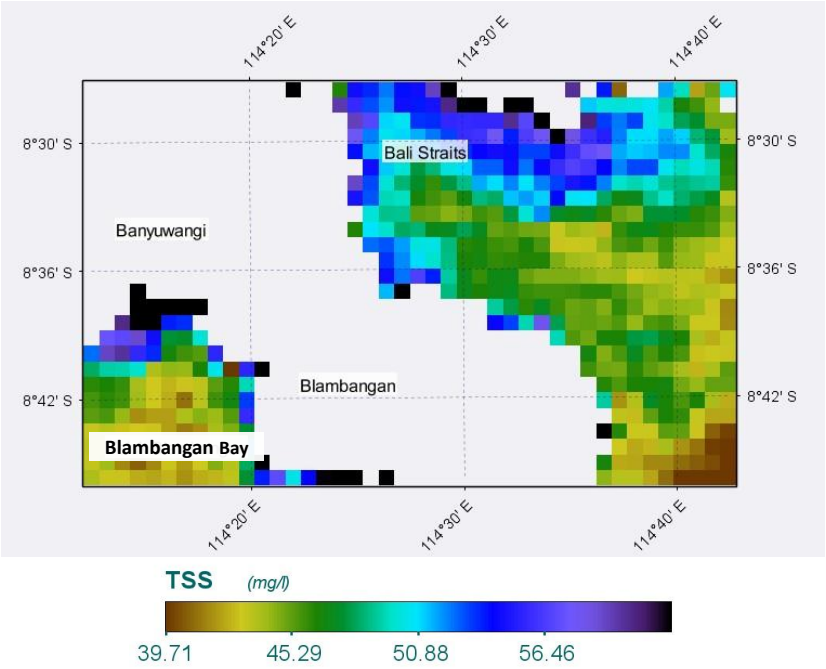

Figure 10. Thematic map of the distribution of TSS values at the Banyuwangi coast on a logarithmic algorithm

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Special thanks to NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Ocean Color Data; 2018 Reprocessing. NASA OB.DAAC, Greenbelt, MD, USA. DOI: data/10.5067/AQUA/MODIS/L2/OC/2018. Accessed on 01/17/2020., and also thanks to students who have helped in the field for retrieving the seawater samples.

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