2nd International Conference Eco-Innovation in Science, Engineering, and Technology
Volume 2021
http://dx.doi.org/10.11594/nstp.2021.1444

NST PROCEEDINGS

OPEN ACCESS

Conference Paper

The Mathematics Model Analysis of Distribution Concentration of Total Suspended Solid in Gresik Coastal Coast with Landsat 8 Satellite Imagery

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ABSTRACT

Total suspended solid is one of the useful parameters to detect the turbidity level that occurs in the body of water. The concentration distribution from total suspended solid is an activity that is quite interesting to study especially in the coastal areas, knowing the distribution value of total suspended solids, it is possible to know the change of ecosystem. The Ujung Pangkah Gresik is an area chosen as an example to determine the distribution concentration of total suspended solid value by making an appropriate mathematical model that can imagine the condition of the body of water in that coastal area. Thus, the purpose of this study was to investigate the mathematics model analysis to imagine the distribution concentration of total suspended solids. The method to model this is by remote sensing that was used in Landsat 8 satellite imagery. In addition, this study used the remote sensing method on the visible light canal (red, green, and blue) to determine the mathematics model analysis of total suspended concentration distribution. The result showed that there was red canal has significant image result compared to another visible canal. The red canal result showed the mathematics model exponential with correlation value R 0.873 has a significant effect to image the total suspended solids concentration distribution. This study concludes that Landsat 8 satellite image can quite effectively and accurately be used to map the distribution of total suspended solid especially in the shallow water environment adjacent to ponds and estuary.

Keywords: Total suspended solid, Landsat 8, mathematics model, visible light canal

Introduction

The coast of Ujung Pangkah Gresik is a very dynamic area for the growth and distribution of total suspended solid concentrations. The Bengawan Solo as a big river on the Java island has quite an impact on the surface of the surrounding areas. This river carries a large suspended load at all times so that it has a lot of impact on the growing ecosystem of marine life on the coast.

The preliminary studies about the distribution of total suspended solids values have been widely studied, including in Indonesia where some shallow coastal areas are in great demand because in this area the distribution of turbidity varies greatly depending on coastal flows and waves. Thus, remote sensing technology has been used to investigate the distribution of total suspended solid where the researchers have been widely used any variant of sensor that was carried by space satellites such as SPOT (Lo & Gunasiri, 2014), Aqua MODIS (Cherukuru et al., 2021; Neukermans et al., 2009; Ondrusek et al., 2012; Wibisana et al., 2019), Terra MODIS (Feng et al., 2012; Moreno-madrinan et al., 2010; Zainab et al., 2020; Brando et al., 2006), Landsat 7 (Deng et al., 1979; Miller et al., 2011), and Landsat 8 (Iswari, 2016; Parwati et al., 2013; Nazirova

How to cite:
Wibisana, H., Handajani, N., & Wardhani, P. C. (2021). The mathematics model analysis of distribution concentration of total suspended solid in gresik coastal coast with Landsat 8 Satellite Imagery. *2nd International Conference Eco-Innovation in Science, Engineering, and Technology*. NST Proceedings. pages 288-294. doi: 10.11594/ nstp.2021.1444

et al., 2021). The use of variations of sensor also attracts some researchers because using the differences kinds of sensors, it is also possible to carry out further exploration of the parameters that are widely taken as research materials, including sea surface temperature and salinity apart from the value of the distribution of turbidity, all of which have a significant impact. Less favorable for the ecosystems that exist in the aquatic environment, especially shallow waters such as those owned by the coast of Ujung Pangkah Gresik. Thus, the purpose of this study was to model the imagery data satellite that was obtained by the total concentration of suspended solid that was taken directly in the field, so that the mathematical model will be able to provide an overview of changes in the amount of total suspended solid concentration on the coast which will also provide an overview of a management quality on the coastal areas for the future.

Data of satellite imagery used is data from Landsat 8 OLI that has 11 canals. In addition, this study was used the visible light canals; red, green, and blue according to some study that was investigated using Landsat 8, the visible light canals has high relatively compatible especially with the mathematics model of the single canal (Eom et al., 2011; Neukermans et al., 2009; Pahlevi, 2013).

Research Method

Research location

This research location was taken on the coastal area of Ujung Pangkah Gresik with the longitude and latitude coordination that was shown in Picture 1. The latitude of the research area is 6^0 52' S to $7^0$10'S, therefore the longitude area of this research is 112^0 30' E to $112^0$45'E.

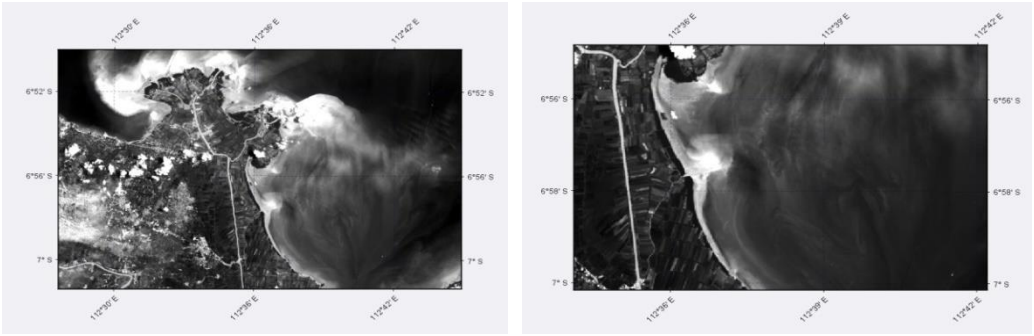

Figure 1. (a) Landsat 8 Satellite Imagery as a research location in Coastal Ujung Pangkah Gresik; Fig. 1(b) Landsat 8 Satellite image result from cropped initial record image on Ujung Pangkah Gresik Coastal Area

Imagery satellite

This study investigated the concentration distribution of total suspended solid using Landsat 8 OLI imagery satellite with 11 canals on the sensor. The imagery satellite can be downloaded free and open access on the website link https://earthexplorer.usgs.gov/ by using the chosen path on 118 and row 65 to choose the scene record of satellite imagery.

The downloaded imagery satellite is Landsat 8 OLI that was downloaded on March 12, 2021, that has been corrected geometrically and radio-metrically. The downloaded imagery satellite file was named LC08_L1TP_118065_20210312_20210317_01_T1_B2_subset1.data, for blue canal; LC08_L1TP_118065_20210312_20210317_01_T1_B3_subset1.data, for green canal; LC08_L1TP_118065_20210312_20210317_01_T1_B4_subset1.data, for red canal. The satellite image obtained is cropped the image to get the clearer data image and detailed area study, the image result showed on Figure 2.

Figure 2. Location of Total Suspended Solid data collection point (mg/l) in the field

Total suspended solids

Total suspended solids were obtained by taking samples in the field using 1-liter plastic bottles and water samples were taken at a depth of 20-30 centimeters from sea level. The data obtained is adjusted to the coordinates of the place of data collection and the results are shown in Table 1, the value is obtained utilizing the Gravimetric method carried out in the laboratory following the work carried out by Terry.

Table 1. Total Suspended Solid sample data at the appropriate coordinates on the coast of Ujung Pangkah Gresik

Longitude	Latitude	TSS (mg/l)
112,6176	-6,9271	104,8
112,6241	-6,9772	73,7
112,6319	-6,9723	78,1
112,6308	-6,9664	66,3
112,6281	-6,9615	65,6
112,6242	-6,9561	62,4
112,6210	-6,9506	82,5
112,6180	-6,9444	68,9
112,6174	-6,9376	79,6
112,6212	-6,9314	81,8
112,6247	-6,9257	74,9
112,6111	-6,9298	147,3
112,6239	-6,9194	79,4
112,6076	-6,9333	138,2
112,6082	-6,9401	85,1
112,6098	-6,9469	112,5
112,6118	-6,9542	146,5
112,6153	-6,9602	152,7
112,6202	-6,9669	98,2
112,6238	-6,9721	83,7

Result and Discussion

From the processing of satellite data images using the least square method, the existing mathematical model can be described, namely, the linear model is shown in Fig. 3 with an R2 correlation value of 0.9026.

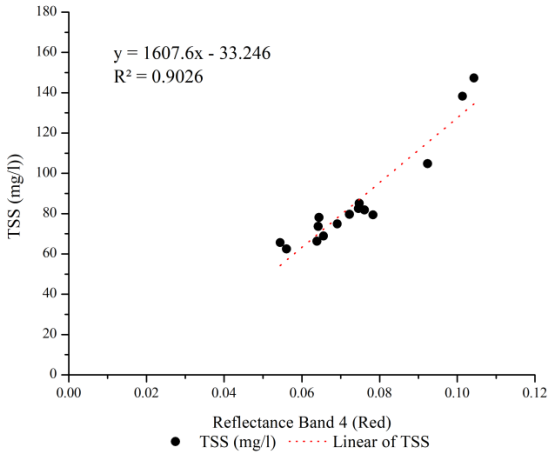

Figure 3. TSS distribution with Linear models at Band 4 (red)

Figure 4. Shows a graph of image data processing for the exponential model on the red channel with an R2 correlation value of 0.9385, while the logarithmic model is shown in Fig. 5 with an R2 correlation value of 0.8457, and the power model is shown in Fig. 6 with an R2 correlation value is 0.8988. From the result on Fig. 3 to Fig. 6 it can be seen that the exponential mathematical model has a better correlation value of R2 than other models, these results are summarized in Tab. 2 which displays several mathematical models used and the correlation value relationships possessed by each model.

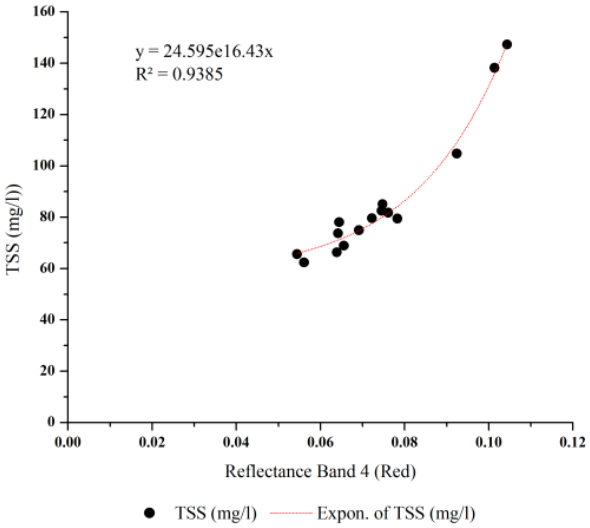

Figure 4. TSS distribution with Exponent models at Band 4 (red)

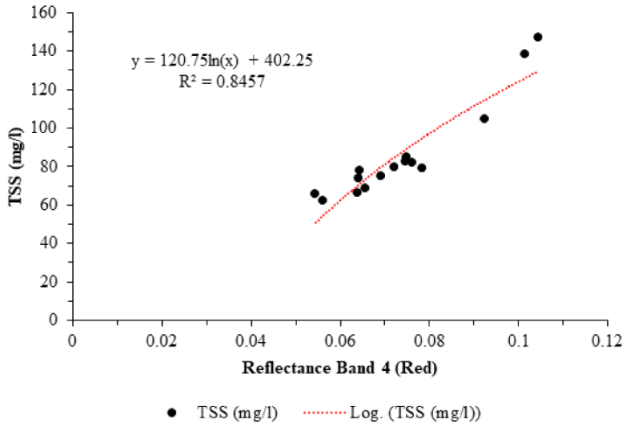

Figure 5. TSS distribution with Logarithmic models at Band 4 (red)

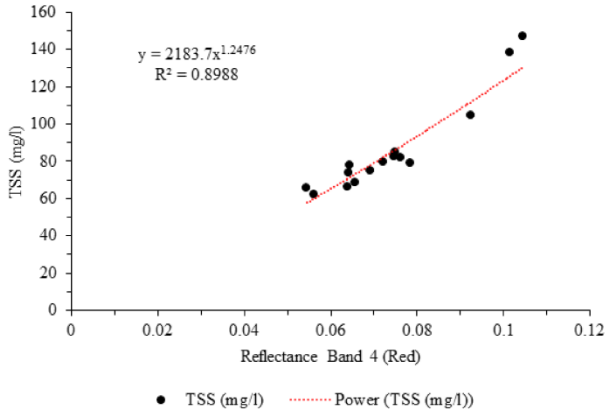

Figure 6. TSS distribution with Power models at Band 4 (red)

The summary of the results of the calculation of the mathematical model used in the measurement of the distribution of total suspended solids is shown in Tab. 2 for the measurement of the red channel from the Landsat 8 OLI image, the highest R^2 value is obtained by the exponential model so that this model will be taken to be compared to other channels from the Landsat 8 image.

Table 2. Mathematics model of concentration of TSS (mg/l) on the red canal

No	Nama	Mathematical model	R^2
1	Linear	y = 1607,6x - 33,246	0.9026
2	Exponent	$y = 24{,}595e^{16{,}43x}$	0.9385
3	Logarithmic	y = 120,75ln(x) + 402,25	0.8457
4	Power	$y = 2183{,}7x^{1{,}2476}$	0.8988

Table 3 is a summary of the calculation results for measurements on the use of green channels and the optimal correlation value is the exponential model with a value of $R^2 = 0.2832$.

Table 3. Mathematics model of concentration of TSS (mg/l) on the green canal

No	Nama	Mathematical model	R^2
1	Linear	y = 2010,6x - 123,76	0,2752
2	Exponent	$y = 8{,}2003e^{22{,}209x}$	0,2832
3	Logarithmic	y = 204,46ln(x) + 548,51	0,2705
4	Power	$y = 13770x^{2{,}2585}$	0,2802

Table 4. Mathematics model of concentration of TSS (mg/l) on the blue canal

No	Nama	Mathematical model	R^2
1	Linear	y = 3326,9x - 291,84	0,3436
2	Exponent	$y = 1{,}3177e^{36{,}5x}$	0,3754
3	Logarithmic	y = 367,52ln(x) + 885,74	0,3357
4	Power	$y = 547702x^{4{,}0405}$	0,3672

Table 4 shows the measurement results for calculations on the blue channel using the existing model, and the optimal correlation value is obtained by the exponential model with a correlation value of R2 = 0.3754. From Table 2, Table 3, and Table 4, it can be concluded that the red channel gives the best results between the green channel and the blue channel, so for making thematic maps using red channel measurements with the most optimal model, the exponential model.

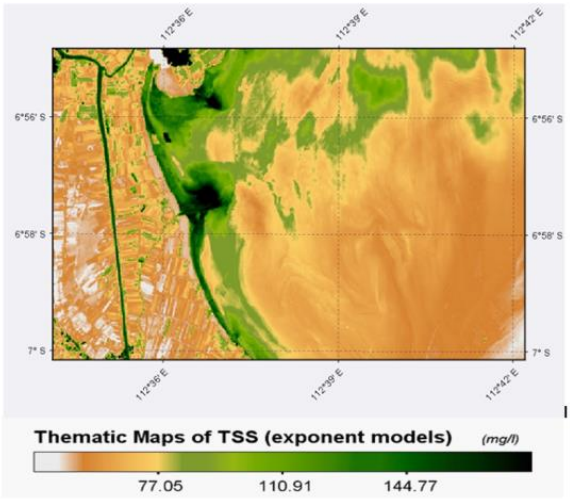

Figure 7. Thematic maps of TSS concentration (mg/l) at Ujung Pangkah Gresik with exponent models at red band Landsat 8 OLI

Figure 7 shows the thematic map of the distribution of total suspended solids that occurs on the east coast of Ujung Pangkah Gresik, adjacent to the island of Madura. The existing legend explains that the distribution of TSS on the Ujung Pangkah coast ranges from an interval of 75 to 150 mg/l of sediment, this is indicated by a color shift from white orange to dark green with TSS values above 140 mg/liter. The green color is closer to the shoreline than the orange color, this indicates that turbidity from suspended solids occurs a lot on the coast where at the Ujung Pangkah estuary the sediment transfer takes place dynamically.

Conclusion

Landsat 8 satellite imagery can be used to map the distribution of TSS values on the coast, especially shallow beaches, and the results shown from the thematic maps are sufficient to provide accurate information about the distribution of turbidity on the coast. The mathematical model that is suitable to describe the distribution of the TSS is an exponential model with a significant correlation value of R2, and this model is generated from calculations on the red channel of the Landsat 8 OLI image. And lastly, the distribution of TSS concentration on the Ujung Pangkah coast has an interval of 75 mg/l to 150 mg/l.

Acknowledgment

The authors thank the "LPPM UPN Veteran East Java" for providing financial assistance via Uber Book batch 2 so that this research can be completed properly and correctly. Also to the USGS Nasa team via the website https://earthexplorer.usgs.nasa.gov/ which has provided Landsat satellite images that can be downloaded for free.

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