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Comparative Analysis Of Aqua MODIS and VIIRS Sensors In Mapping Chlorophyll-A Concentration and Sea Surface Temperature In The South Coast Of East Java

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Abstract. *The South Coast of East Java is one of the areas that has marine and fisheries potential. This is utilized by local residents as a source of livelihood. To maximize this potential, it is necessary to know how the water quality in an area. The water quality of a water body can be known through the measurement of chlorophyll-a concentration and sea surface temperature with the help of remote sensing technology. This study aims to analyze the comparison of Aqua MODIS and VIIRS images on mapping chlorophyll-a concentration and sea surface temperature with the help of the SeaDAS application whose data is downloaded through the NASA oceancolor website. To map chlorophyll-a concentration and sea surface temperature, an analysis method using the most optimal mathematical model is needed. The results of the Aqua MODIS satellite image chlorophyll-a concentration research in the year (2020-2024) in the South Coast of East Java has an average of 0.24282 mg/m^3, 0.19144 mg/m^3, 0.51777 mg/m^3, 0.37524 mg/m^3, and 4.0542 mg/m^3. The highest average chlorophyll-a concentration value of Aqua MODIS satellite imagery occurred in May 2024. This condition indicates that the water quality in the South Coast of East Java is low. While the chlorophyll-a concentration of VIIRS satellite images in the year (2020-2024) in the South Coast of East Java has an average of 0.23197 mg/m^3, 0.31974 mg/m^3, 0.19304 mg/m^3, 0.38974 mg/m^3, and 1.58583 mg/m^3. The highest average chlorophyll-a concentration value of VIIRS satellite imagery occurred in May 2024. This condition indicates that the water quality in the South Coast of East Java is low.*

Keywords *Chlorophyll-a, Sea Surface Temperature, Aqua MODIS, VIIRS*

1. INTRODUCTION

The South Coast of East Java is one of the areas that has marine and fisheries potential. This is utilized by local residents as a source of livelihood. To maximize this potential, it is necessary to know how the water quality in an area. The water quality of a water body can be known through the measurement of chemical and physical parameters. Parameters that determine the fertility of waters include chlorophyll-a. The distribution of chlorophyll-a is influenced by the intensity of light and nutrients contained in a body of water that can cause the level of chlorophyll-a productivity. The level of water fertility will be high if the distribution of chlorophyll-a is high and vice versa, the level of water fertility will be low if the distribution of chlorophyll-a is low.

Besides chlorophyll-a, sea surface temperature (SST) is also a key parameter that affects water quality. According to Sukresno (2008), SPL acts as a major factor in driving the seasonal cycle in the tropics and subtropics, affecting weather conditions, seasons, and the marine atmosphere. SPL can affect water fertility and fisheries activities. Therefore, monitoring and analyzing SST is essential for understanding the dynamics of the marine

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environment. Mapping the Correlation between Sea Surface Temperature and Chlorophyll-a Concentration was conducted with the help of Remote Sensing technology.

Remote sensing is the science and art of getting information about an object, area, or phenomenon by analyzing data collected with a tool while maintaining no direct contact with the object, area, or phenomenon under study. (Lillesand & Kiefer, 1979). Marine/fisheries remote sensing can help understand the dynamics of the coastal and marine environment including understanding the dynamics of the natural resources contained therein, especially those related to fisheries (Syah, 2010).

The instruments used in remote sensing are satellites. Aqua Modis satellite images have the ability to observe the entire surface of the earth every one or two days. While VIIRS (Visible Infrared Imaging Radiometer Suite) is one of the main instruments on the S-NPP (Suomi National Polar-orbiting Partnership) satellite.

Mapping chlorophyll-a concentration and sea surface temperature requires analysis using the most optimal mathematical model. The method used for known data is the Anova test. The results of the comparison of mapping using Aqua Modis and VIIRS sensors are then used as one of the parameters for monitoring water quality such as determining fish catch areas and ecosystem conservation. This research aims to analyze the comparison of Aqua MODIS and VIIRS images in mapping chlorophyll-a concentration and sea surface temperature with the help of the SeaDAS application.

2. LITERATURE REVIEW

Previous Research

1. Wibisana et al. (2018) under the heading "Determination of the Optimal Mathematical Model of Sea Surface Temperature on the Gresik North Coast Based on Aqua Modis Satellite Image Reflectance Values." The goal of this work was to obtain the optimum mathematical model for simulating sea surface temperature using Aqua Modis level 2 satellite photos. Using a thermometer, in-situ measurements of the sea surface temperature were made at up to 20 different point locations along the Gresik coast near Ujungpangkah. The Ms. Excel application was used to determine the most efficient algorithm. The linear, exponent, logarithmic, polynomial, and power forms are used to calculate the equation model. The wavelengths at which the mathematical model is calculated are 443 nm, 531 nm, and 667 nm. The 667 nm channel yielded the most ideal results from the calculation of the three waves. The mathematical model for this channel

is a cubic polynomial with the following equation: T = -4E+09(Rrs_667)3 + 1E+07(Rrs_667)2 - 14356(Rrs_667) + 30.934, where R = 0.901.

2. Zainab et al. (2019) with the heading "Aqua Modis Satellite Image Data: A Comparative Analysis of Chlorophyll-a Concentration in Blambangan Peninsula, Banyuwangi Regency." The purpose of this study is to compile a summary of the amount of chlorophyll-a in the areas surrounding Blambangan Bay and the Peninsula. There are twenty coordinate points total, ten of which are on the Blambangan Peninsula and ten more of which are in Blambangan Bay. The greatest correlation, Chlor-a = 21228 * (Rrs_531)-42.371 with an R^2 value of 0.7951, is found at a wavelength of 531 nm green light, which is the best appropriate mathematical model for Blambangan Bay circumstances according to this study. It is found that the average concentration of chlorophyll-a in the Blambangan Peninsula in August 2017 was 18.45 ppt (mg/m^3), which is pretty substantial. Based on this, it can be projected that the fish population in these waters will likewise rise in August 2017.
3. Putri et al. (2020) under the heading "Aqua Modis Satellite Image Data: The Best Mathematical Model for Mapping Sea Surface Temperature in Coastal Jember." The purpose of this study is to evaluate the sea surface temperature (SPL) in the Jember coastal area from January to April 2020 using mathematical models. An indirect strategy was used to conduct this study, with data taken from Aqua Modis satellite imagery. There are twenty coordinate points that need to be examined as objects. With the use of linear graph equations, exponents, logarithms, and power for each wavelength of 412 nm, 531 nm, and 667 nm, the mathematical model is calculated using the Ms Excel application. The calculation results show that the most ideal mathematical model has an equation y = -0.86ln(x) + 25.709 and a wavelength of 531 with an R2 of 0.2754.
4. Mursyidin et al. (2015) "Prediction of Fishing Zone Using Chlorophyll-a Image and Aqua MODIS Satellite Sea Surface Temperature Image in Pulo Aceh Waters" is the title of the project. This study describes the use of Aqua Modis satellite image data to forecast fish harvest zones based on the distribution of chlorophyll-a and sea surface temperature. Monthly SIM (Standard Mapped Image) level 3 image data is the type of image data used. The utilized image has a spatial resolution of 4 km and covers the period from May to August 2014. The kriging model interpolation approach was then used to the collected data. Kriging is a geostatistical data analysis method. In June 2014, the highest chlorophyll-a distribution image yielded extraction findings valued at 2.57 mg/m3. In June, the sea surface temperature varied between 29.15°C and 30.47°C.

5. Nababan et al. (2022) titled "Sea Surface Temperature Variability and Chlorophyll-a Concentration in the Northeast Indian Ocean, West of Sumatra." The purpose of this study is to ascertain the variability of SPL and Chl-a in the Northeast Indian Ocean near Sumatra, as well as the factors that influence that variability. SPL data from MODIS level 3 satellite pictures and NOAA-AVHRR level 3 data were the sources of the data. Chl-a from MODIS level 3 photos and SeaWiFS were used in the data. The results of the calculation of the monthly average SPL in the Northeast Indian Ocean west of Sumatra from NOAA-AVHRR and MODIS image data in 1997-2019 ranged from 27.57℃ to 34.41℃, while the results of the calculation of the monthly average Chl-a concentrations from SeaWiFS and MODIS image data in 1997-2019 ranged from 0.0757 mg/m^3 to 1.3006 mg/m^3.

Geographic Information System

Gistut (1994) explains that a Geographic Information System is a system that can be used to support decision making and is able to integrate descriptions of locations with characteristics of phenomena found in the field or location under review.

Geographic information systems are information systems made to deal with data that is spatially referenced or geographically coordinated, according to Barus B. & U. S. Wiradisastra (2000).

Remote Sensing

According to Lillesand, Kiefer and Chipman (1979) Remote sensing is the science and art of getting information about an object, area, or phenomenon by analyzing data collected with a tool while maintaining no direct contact with the object, area, or phenomenon under study.

According to Parsons (1985), Remote sensing is the process of taking pictures of the earth's surroundings using electromagnetic radiation sensors, which are then analyzed to produce insightful data.

According to Colwell R. N. (1984) says that the measurement or collection of object data on the surface of the planet from satellites or other devices that are far away from the viewed thing is known as remote sensing.

Aqua MODIS

MODIS is a satellite instrument that functions on both Terra and the Aqua spacecraft. The MODIS sensor is a derivative of the EOS (Earth Observing System) sensors AVHRR (Advance Very High Resolution Radiometer), Sea WiFS (Sea-viewing Wide Field of View Sensor), and HIRS (High Resolution Imaging Spectrometer), which were previously in orbit. This allows it to measure parameters from the sea surface to the atmosphere, such as the concentration of chlorophyll, the temperature of the sea surface, the water vapor content, and marine phenomena like thermal fronts and upwelling.

VIIRS (Visible Infrared Imaging Radiometer Suite)

VIIRS is one of the primary instruments on the S-NPP (Suomi National Polar-orbiting Partnership) satellite. VIIRS is an improved MODIS instrument that is now operating on the EOS Terra and Aqua spacecraft.

SeaDAS (SeaWiFS Data Analysis System)

SeaDAS is an environmental data processing application developed by the United States space agency NASA (National Aeronautics and Space Administration). SeaDAS is commonly used in processing, exporting environmental data, for example: sea surface temperature data, and ocean current velocity and many more. In this research, SeaDAS software version 7.5.3 is used.

Sea Surface Temperature

Sea Surface Temperature is one of the abiotic factors that has a major influence on the life and growth of aquatic organisms, where each aquatic organism has different characteristics of water temperature conditions suitable for its survival. Changes in SPL cause variations in marine life and related oceanographic factors. Sukojo et al. (2009).

Chlorophyll-a

According to Sihombing et al. (2013) Chlorophyll-a is one of the parameters used to detect the population of phytoplacton in the aquatic environment. As one of the parameters, the measurement of the concentration of chlorophyll-a will show the fertility level of a water body, where with a lot of chlorophyll-a content it can be ascertained that the distribution of phytoplacton is also large, and in the end with a large phytoplacton content will attract fish to forage in the aquatic environment. Based on the trophic status of the water, the concentration

of chlorophyll-a can be categorized: 0–2 mg/m3 is considered oligotrophic, 2–5 mg/m^3 is considered meso-oligotrophic, 5–20 mg/m^3 is considered mesotrophic, 20–50 mg/m^3 is considered eutrophic, and more than 50 mg/m^3 is considered hyper-eutrophic (Arifin, 2009).

3. METHODS

The research project is a descriptive quantitative one that intends to compare Aqua MODIS and VIIRS pictures in mapping chlorophyll-a concentration and sea surface temperature using the SeaDAS program. The research site is located on the South Coast of East Java Province with coordinates ranging from 8º 5' 58.91“ - 8º 30‘ 55.99” South latitude and 110º 50' 7.95“ - 114º 29’ 37.83” East longitude, precisely along the coast of Pacitan Regency, Tulungagung Regency, Malang Regency, Jember Regency, Banyuwangi Regency.

Problem Identification

Indonesia's geographical location is at the crossroads of world trade routes. Therefore, the utilization of marine and fisheries potential is very necessary. One of the Indonesian waters that has marine and fisheries potential is the southern coastal waters of East Java. The purpose of this research is to compare Aqua MODIS and VIIRS pictures for correlation mapping of chlorophyll-a concentration and sea surface temperature using the SeaDAS application. Furthermore, an ANOVA test must be performed on data collected within the last five years (2020-2024). Analyzing chlorophyll-a content and sea surface temperature can provide information about the quality and fertility of these waters.

Data Collection Technique

The research employed secondary data from Aqua MODIS and VIIRS imagery. Secondary data is information received indirectly from the subject or item at the research location. Secondary data obtained from this study are:

1. CitraAquaMODIS(https://oceancolor.gsfc.nasa.gov/):
   AQUA_MODIS.20200523T061501.L2.OC.nc(2020)
   AQUA_MODIS.20210424T061500.L2.OC.nc(2021)
   AQUA_MODIS.20220621T060501.L2.OC.nc(2022)
   AQUA_MODIS.20230527T062001.L2.OC.nc(2023)
   AQUA_MODIS.20240514T064501.L2.OC.NRT.nc (2024)

2. Citra VIIRS (https://oceancolor.gsfc.nasa.gov/) :
   SNPP_VIIRS.20200612T054800.L2.OC.nc(2020)
   SNPP_VIIRS.20210416T061200.L2.OC.nc(2021)
   SNPP_VIIRS.20220414T060600.L2.OC.nc(2022)
   SNPP_VIIRS.20230530T060000.L2.OC.nc(2023)
   SNPP_VIIRS.20240516T060001.L2.OC.NRT.nc (2024)

Data Processing

After downloading data through the Oceancolor website, several stages are carried out for data processing. The following are the stages of data processing in this study:

1. Researchers determine the location that will be reviewed for chlorophyll-a concentration data and sea surface temperature.
2. Researchers determine the data that will be downloaded on the Oceancolor website.
3. The data that has been downloaded is then processed in the SeaDAS software and image cropping is done.
4. After cutting the image, reproject using WGS 1984 (automatic).
5. Then select the research location using the pin placing tool.
6. After making the pin location then open the managed placement of the pins menu.
7. The next step to display the data value click the filter menu pixel data to be displayed in the table.
8. The data that has been displayed is then copied and pasted into the Ms. Excel application.

Research Tools

In the process of collecting data, several tools are needed to help and facilitate this research process. The tools needed are divided into two, namely hardware and software as follows:

a. Hardware includes:
   1. Laptop / Computer to run the software.
b. Software includes:
   1. SeaDAS software to analyze data from satellite images.
   2. Microsoft Office Word 2016 and Microsoft Excel 2016 to compile research and analyze data.

4. RESULTS

The data that has been obtained is then processed with the help of the MS application. Excel. In making thematic maps, the best algorithm equation is needed by knowing the degree of determination (R2). The recapitulation of Aqua MODIS and VIIRS satellite image data processing is shown in the following table.

Table 1. Recapitulation of Chlorophyll-a and Sea Surface Temperature Data Processing Results Aqua MODIS and VIIRS Satellite Images.

No	Year	Satellite Imagery	Type of Equation	Algorithm Model	Degree of Determinasi
1	2020	Aqua MODIS	*Linear*	y = -0.018x + 0.7922	R^2 = 0.0159
2	2020	VIIRS	*Linear*	y = -0.0916x + 2.9584	R^2 = 0.072
3	2021	Aqua MODIS	*Linear*	y = 0.0175x - 0.3252	R^2 = 0.0023
4	2021	VIIRS	*Linear*	y = -0.0085x + 0.5706	R^2 = 0.0014
5	2022	Aqua MODIS	*Linear*	y = 0.0364x - 0.5672	R^2 = 0.0005
6	2022	VIIRS	*Linear*	y = 0.021x - 0.4371	R^2 = 0.0079
7	2023	Aqua MODIS	*Linear*	y = -0.541x + 15.591	R^2 = 0.6202
8	2023	VIIRS	*Linear*	y = -0.2011x + 5.961	R^2 = 0.2547
9	2024	Aqua MODIS	*Linear*	y = -7.5661x + 201.54	R^2 = 0.4697
10	2024	VIIRS	*Linear*	y = -1.1307x + 31.431	R^2 = 0.3205

After finding the best algorithm equation model, replace the value of x in the algorithm equation with the value of sea surface temperature to find the correlation between sea surface temperature and chlorophyll-a concentration. Then, using the data analysis program in MS Excel, determine the data's mean, variance, standard deviation, and standard error. A recapitulation of the calculation of the mean, variance, standard deviation, and standard error of the correlation of sea surface temperature to chlorophyll-a concentration of Aqua MODIS and VIIRS satellite images is shown in Table 2 below.

Table 2. Recapitulation of Mean, Variance, Standard Deviation, and Standard Error of Correlation of Sea Surface Temperature to Chlorophyll-a Concentration of Aqua MODIS and VIIRS Satellite Images.

No	Year	Satellite Imagery	Mean	Variance	Standard Deviation	Standard Error
1	2020	Aqua MODIS	0.2428	0.0001	0.0120	0.0012
2	2020	VIIRS	0.2320	0.0011	0.0326	0.0033
3	2021	Aqua MODIS	0.1914	1.19287E-05	0.0035	0.0003
4	2021	VIIRS	0.3197	1.14768E-05	0.0034	0.0003
5	2022	Aqua MODIS	0.5178	6.99569E-05	0.0084	0.0008
6	2022	VIIRS	0.1930	5.06494E-05	0.0071	0.0007
7	2023	Aqua MODIS	0.3752	0.088197831	0.2970	0.0297
8	2023	VIIRS	0.3897	0.005701378	0.0755	0.0076
9	2024	Aqua MODIS	4.0542	12.24847768	3.4998	0.3500
10	2024	VIIRS	1.5858	0.4433	0.6658	0.0666

From table 2 above, the highest average chlorophyll-a concentration value occurs in 2024 with Aqua MODIS satellite imagery. This condition indicates that the water quality in the South Coast of East Java is low.

The next analysis is processing satellite image data in 2020-2024 using the MS. Excel application with the ANOVA model: Two Factor Without Replication to find out any differences between satellite images in 2020-2024. The data processing is shown in tables 3 and 4 below.

Table 3. F-count Results of Chlorophyll-a Concentration Analysis of Aqua MODIS Satellite Imagery.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	265.8455	99	2.685308	1.112897	0.238466	1.284607
Columns	1114.9	4	278.725	115.5146	3.46E-65	2.394476
Error	955.5077	396	2.412898			
Total	2336.253	499				

Rows data processing is the comparison of data in one coordinate compared to other annual data, the table shows that F count is smaller than F crit with a value of 1.112897 < 1.284607 meaning H_1 is rejected, while the P-value is greater than the α value of 0.238466 > 0.05 which means there is no difference between the image data of chlorophyll-a concentration in 2020 - 2024.

Column data processing shows that F count is greater than F crit with a value of 115.5146 > 2.394476, meaning H_0 is rejected, while the P-value is smaller than the α value of 3.46-65 < 0.05, which means there is a difference between the image data of chlorophyll-a concentration in 2020 - 2024. This is due to the changing weather conditions each year, causing differences in chlorophyll-a concentration values each year.

Table 4. F-calculation Results of Chlorophyll-a Concentration Analysis from VIIRS Satellite Imagery.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	10.09784	99	0.101998	1.171998	0.148009	1.284607
Columns	138.005	4	34.50124	396.4318	5.4E-137	2.394476
Error	34.46366	396	0.087029			
Total	182.5665	499				

Row data processing is a comparison of data in one coordinate compared to other annual data, the table shows that F count is smaller than F criterion with a value of 1.171998 < 1.284607 which means H_1 is rejected, while the P-value is greater than the α value of 0.148009 > 0.05 which means there is no difference between chlorophyll-a concentration image data in 2020 - 2024.

Column data processing shows that F count is greater than F criterion with a value of 396.4318 > 2.394476 which means H_0 is rejected, while the P-value is smaller than the α value of 5.4-137 < 0.05 which means there is a difference between image data of chlorophyll-a concentration in 2020 - 2024. This is caused by weather conditions that change every year, causing differences in the value of chlorophyll-a concentration every year. Furthermore, a thematic map of the correlation between sea surface temperature and chlorophyll-a concentration was made.

To create a thematic map of the correlation between sea surface temperature and chlorophyll-a concentration, the SeaDAS application needs help by entering the algorithm model that has been obtained and then opening it in the Math Band program. After entering the algorithm model with the x value as sea surface temperature, a thematic map will be extracted. The thematic map of the correlation of sea surface temperature to chlorophyll-a concentration of Aqua MODIS and VIIRS satellite images can be shown in the following figure.

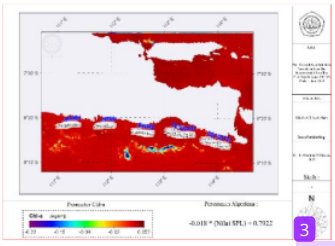

Figure 1. Thematic map of the correlation between sea surface temperature and chlorophyll-a concentration of Aqua MODIS satellite images in 2020.

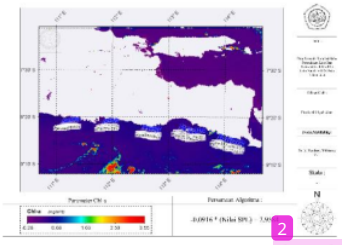

Figure 2. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration VIIRS Satellite Image in 2020.

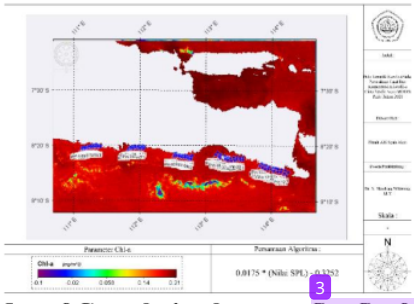

Figure 3. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration Aqua MODIS Satellite Image in 2021.

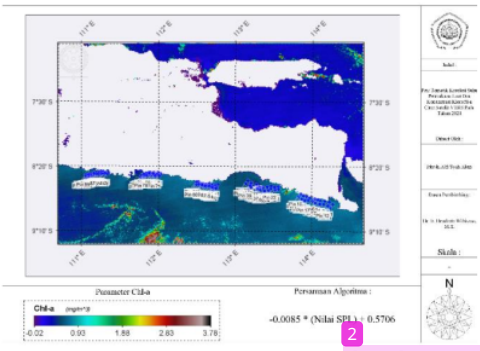

Figure 4. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration VIIRS Satellite Image in 2021.

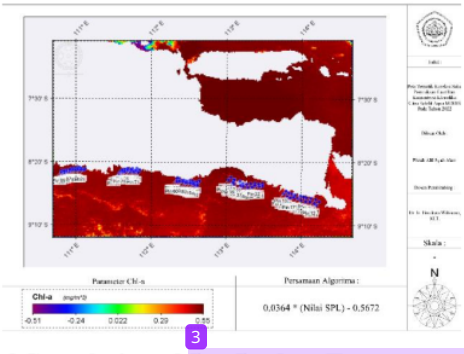

Figure 5. Thematic Map of Correlation of Sea Surface Temperature and Chlorophyll-a Concentration of Aqua MODIS Satellite Image in 2022.

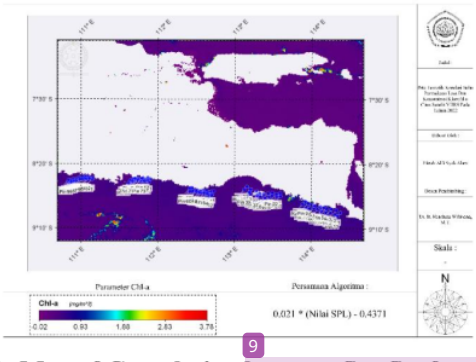

Figure 6. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration VIIRS Satellite Image 2022.

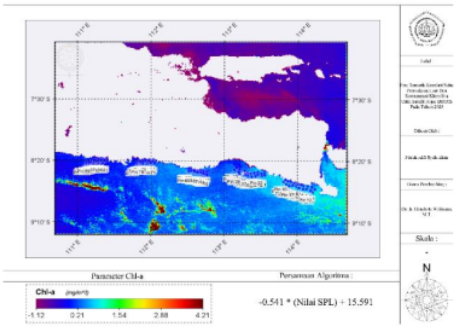

Figure 7. Thematic Map of Correlation of Sea Surface Temperature and Chlorophyll-a Concentration of Aqua MODIS Satellite Image in 2023.

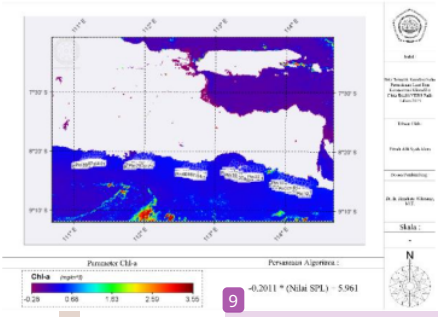

Figure 8. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration VIIRS Satellite Image 2023.

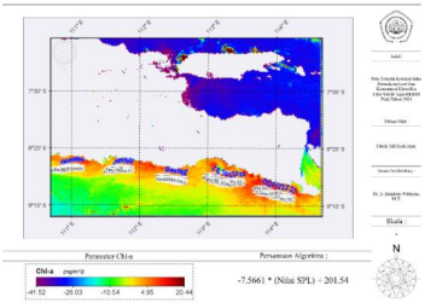

Figure 9. Thematic Map of Correlation of Sea Surface Temperature and Chlorophyll-a Concentration of Aqua MODIS Satellite Image in 2024.

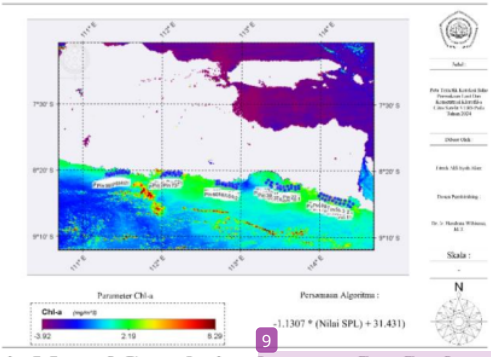

Figure 10. Thematic Map of Correlation between Sea Surface Temperature and Chlorophyll-a Concentration VIIRS Satellite Image 2024.

5. CONCLUSION

1. Chlorophyll-a concentration of Aqua MODIS satellite images in the year (2020-2024) on the South Coast of East Java has an average of 0.24282 mg/m^3, 0.19144 mg/m^3, 0.51777 mg/m^3, 0.37524 mg/m^3, and 4.0542 mg/m^3. The highest average chlorophyll-a concentration value of Aqua MODIS satellite imagery occurred in May 2024. This condition indicates that the water quality on the South Coast of East Java is low. Chlorophyll-a concentration of VIIRS Satellite Image in the year (2020-2024) in the South Coast of East Java has an average of 0.23197 mg/m^3, 0.31974 mg/m^3, 0.19304 mg/m^3, 0.38974 mg/m^3, and 1.58583 mg/m^3. The highest average chlorophyll-a concentration value of VIIRS satellite imagery occurred in May 2024. This condition indicates that the water quality on the South Coast of East Java is low.
2. The results of the ANOVA test of the chlorophyll-a concentration of Aqua MODIS satellite imagery on rows data processing is a comparison of data in one coordinate compared to other annual data, the table shows that F count is smaller than F crit with a

value of 1.112897 < 1.284607 meaning H_1 is rejected, while the P-value is greater than the α value of 0.238466 > 0.05 which means there is no difference between the image data of chlorophyll-a concentration in 2020 - 2024. The columns data processing shows that F count is greater than F crit with a value of 115.5146 > 2.394476, meaning H_0 is rejected, while the P-value is smaller than the α value of 3.46-65 < 0.05, which means there is a difference between the image data of chlorophyll-a concentration in 2020 - 2024. This is due to the changing weather conditions each year, causing differences in chlorophyll-a concentration values each year.

The results of the ANOVA test of chlorophyll-a concentration of VIIRS satellite images on rows data processing is a comparison of data in one coordinate compared to other annual data, the table shows that F count is smaller than F crit with a value of 1.171998 < 1.284607 meaning H_1 is rejected, while the P-value is greater than the α value of 0.148009 > 0.05 which means there is no difference between the image data of chlorophyll-a concentration in 2020 - 2024. The columns data processing shows that F count is greater than F crit with a value of 396.4318 > 2.394476, meaning that H_0 is rejected, while the P-value is smaller than the α value of 5.4-137 < 0.05, which means there is a difference between the image data of chlorophyll-a concentration in 2020 - 2024. This is due to the changing weather conditions each year, causing differences in chlorophyll-a concentration values each year. Furthermore, a thematic map of the correlation between sea surface temperature and chlorophyll-a concentration was created.

3. Thematic maps of the correlation of sea surface temperature and chlorophyll-a concentration of Aqua MODIS satellite images are shown in Figures 1, 3, 5, 7, and 9. Thematic maps of the correlation of sea surface temperature and chlorophyll-a concentration of VIIRS satellite images are shown in Figures 2, 4, 6, 8, and 10.

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