Indo-MathEdu Intellectuals Journal

p-ISSN: 2808 – 5604
e-ISSN: 2808 – 5078
Volume. 6, No. 1, 2025

EXAMINING THE INTERRELATIONSHIP AMONG CHLOROPHYLL-A DISTRIBUTION, SEA SURFACE TEMPERATURE PATTERNS, AND FISHING GROUND IN SOUTHERN JAVA SEA

Martin Anjar Ginanjar[1], Andri Wahyudi[2], Lulut Alfaris[3]
[1, 2, 3]Politeknik Kelautan dan Perikanan Pangandaran, Jl. Raya Babakan, Pangandaran, Jawa Barat, Indonesia
Email: martin@pkpp.ac.id

Article History

Received: 12-01-2025

Revision: 22-01-2025

Accepted: 23-01-2025

Published: 24-01-2025

Abstract. The Southern Java Sea is vital for sustaining marine ecosystems and fisheries productivity, shaped by dynamic oceanographic processes. This research investigates the relationship between chlorophyll-a distribution, sea surface temperature (SST) patterns, and the spatial dynamics of fishing grounds in the area. Using satellite-based data from Aqua-MODIS and numerical model outputs, chlorophyll-a levels and SST variability were analyzed on 2024. Descriptive statistics and spatial analysis were applied to identify temporal trends and their connection to productive fishing zones. The results indicate a strong correlation between chlorophyll-a distribution and SST patterns, with seasonal changes significantly influencing fishing ground productivity. These findings provide critical insights for advancing sustainable fisheries management and resource planning in the Southern Java Sea. The study emphasizes the need to incorporate oceanographic indicators into fisheries policies to promote ecosystem health and economic resilience.

Keywords: Chlorophyll-a, Sea Surface Temperature, Fishing Grounds, Southern Java Sea

Abstrak. Laut Jawa bagian selatan memiliki peran penting dalam mendukung ekosistem laut dan produktivitas perikanan, yang dipengaruhi oleh proses oseanografi yang dinamis. Penelitian ini mengkaji hubungan antara distribusi klorofil-a, pola suhu permukaan laut (SST), dan dinamika spasial daerah penangkapan ikan di wilayah tersebut. Data dikumpulkan menggunakan pendekatan berbasis penginderaan jauh dengan memanfaatkan citra satelit dari sensor Aqua-MODIS dan persamaan model numerik, variasi konsentrasi klorofil-a dan SST dianalisis selama tahun 2024. Analisis statistik deskriptif dan spasial diterapkan untuk mengidentifikasi tren temporal serta kaitannya dengan zona penangkapan ikan yang produktif. Hasil penelitian menunjukkan adanya korelasi yang kuat antara distribusi klorofil-a dan pola SST, yang secara signifikan memengaruhi produktivitas daerah penangkapan ikan. Temuan ini memberikan wawasan penting untuk mendukung pengelolaan perikanan yang berkelanjutan dan perencanaan sumber daya di Laut Jawa bagian selatan. Studi ini menekankan pentingnya mengintegrasikan indikator oseanografi ke dalam kebijakan perikanan untuk mendukung kebijakan terkait ekosistem dan ketahanan ekonomi.

Kata Kunci: Klorofil, Suhu Permukaan Laut, Zona Penangkapan Ikan, Laut Selatan Jawa

How to Cite: Ginanjar, M. A., Wahyudi, A., & Alfaris, L. (2025). Examining The Interrelationship Among Chlorophyll-A Distribution, Sea Surface Temperature Patterns, and Fishing Ground in Southern Java Sea. *Indo-MathEdu Intellectuals Journal*. 6 (1), 784-792. http://doi.org/10.54373/imeij.v6i1.2626

INTRODUCTION

Java Island, located in the heart of Indonesia, possesses diverse fishery resources, making its fishing industry highly promising for development. Fisheries are a critical sector expected to enhance the welfare of communities across Java (Setiawati & Tanaka, 2017). Geographically, Java is situated between 6° to 8° South Latitude and 105° to 114° East Longitude, with a marine area consisting of vast coastal zones and an Exclusive Economic Zone / Zona Ekonomi Eksklusif (ZEE) critical to the nation's economy (Kumala et.al, 2023). The southern Java sea hold significant potential for capture fisheries due to their location along the Indian Ocean and their proximity to productive upwelling zones. These waters exhibit distinct oceanographic characteristics influenced by seasonal monsoons and dynamic currents. However, limited oceanographic data has been collected from this region (Hendiarti, 2024). One key challenge faced by local fishermen is the dynamic nature of fishing grounds, which shift constantly in response to environmental conditions (Salas & Gaertner, 2010).

Fish habitats are inherently dynamic, shaped by environmental factors that compel fish to seek optimal living conditions (Gaol et al., 2004). Oceanographic parameters such as sea surface temperature, salinity, chlorophyll-a concentration, weather patterns, and currents play crucial roles in defining these habitats. Remote sensing, particularly through satellite imagery, is an effective tool for monitoring these parameters. Aqua-MODIS satellite imagery, in particular, provides valuable insights into chlorophyll-a concentrations, aiding in the identification of potential fishing grounds (NASA, 2018).

Previous studies have utilized Terra and Aqua MODIS satellite imagery to identify fishery zones, primarily focusing on sea surface temperature (Gao, 2009; Mather & Koch, 2011). Other research has analyzed chlorophyll-a distribution to locate fishing grounds using Geographic Information System (GIS) techniques. These studies demonstrate the potential for predicting fish-rich zones based on chlorophyll-a distribution, with research targeting coastal and offshore waters along Java's southern coastline (Xiong et al., 2005). An analysis of chlorophyll-a distribution in Java's waters conducted by previous researchers revealed variations in chlorophyll-a concentrations influenced by seasonal dynamics and oceanographic conditions. The southern waters of Java generally exhibit higher chlorophyll-a levels compared to other regions, making them particularly significant for fisheries productivity. However, prior studies have not specifically examined chlorophyll-a distribution based on district-level autonomy or recent trends. This study aims to fill this gap by analyzing recent spatial and temporal trends in chlorophyll-a distribution in Java's southern waters, with a focus on district-level variations. Updated research is therefore needed to analyze chlorophyll-a distribution in Java's southern waters, providing essential data for identifying future fishing zones and supporting sustainable fisheries management.

METHOD

The primary data for this study consists of monthly Aqua-MODIS chlorophyll-a imagery for 2024, with a spatial resolution of 4 km x 4 km, obtained through remote sensing techniques. Supplementary data includes sea surface temperature (SST) and salinity, acquired from satellite-derived datasets and validated with in situ measurements from field surveys conducted in key locations within the study area. The study employs a descriptive method combined with a quantitative analysis approach to examine spatial and temporal variations. Chlorophyll-a concentration (CaChl) is calculated using empirical algorithms, such as the Ocean Color algorithms, and processed using advanced geospatial analysis tools to ensure accuracy. These techniques allow for robust identification of patterns and trends in chlorophyll-a distribution relevant to fisheries productivity and ecosystem dynamics.

$$Cchl = 10^{(a0 + a1R + a2R2 + a3R3)} \quad \text{.......(1)}$$

Where:

R (λ) = Remote sensing reflectance at wavelength (λ)
λ1,λ2 = Specific bands for MODIS
a0,a1,a2,a3,a4 = Algorithm coefficients calibrated for the specific sensor and environment.

Sea Surface Temperature is typically derived using thermal infrared bands from satellite sensors, corrected for atmospheric effects using split-window algorithms. For MODIS, a common SST algorithm is:

$$SST = a_0 + a_1T_i + a_2(T_i - T_j) \quad \text{.......(2)}$$

Where:
a_k = coefficients that depend on the spectral response function of the two channels
T = Brightness temperatures at 11 µm and 12 µm channels, respectively.

The descriptive method aims to provide a detailed explanation of events occurring at specific times and locations. Quantitative approach seeks to test theories, establish facts, identify relationships between variables, offer statistical insights, and make predictions. The research was conducted from January to December 2024, focusing on processing satellite-derived chlorophyll-a imagery. The study area encompasses the southern Java Sea, which falls within the jurisdiction of Indonesia’s Fisheries Management Area (WPP-RI) 573.

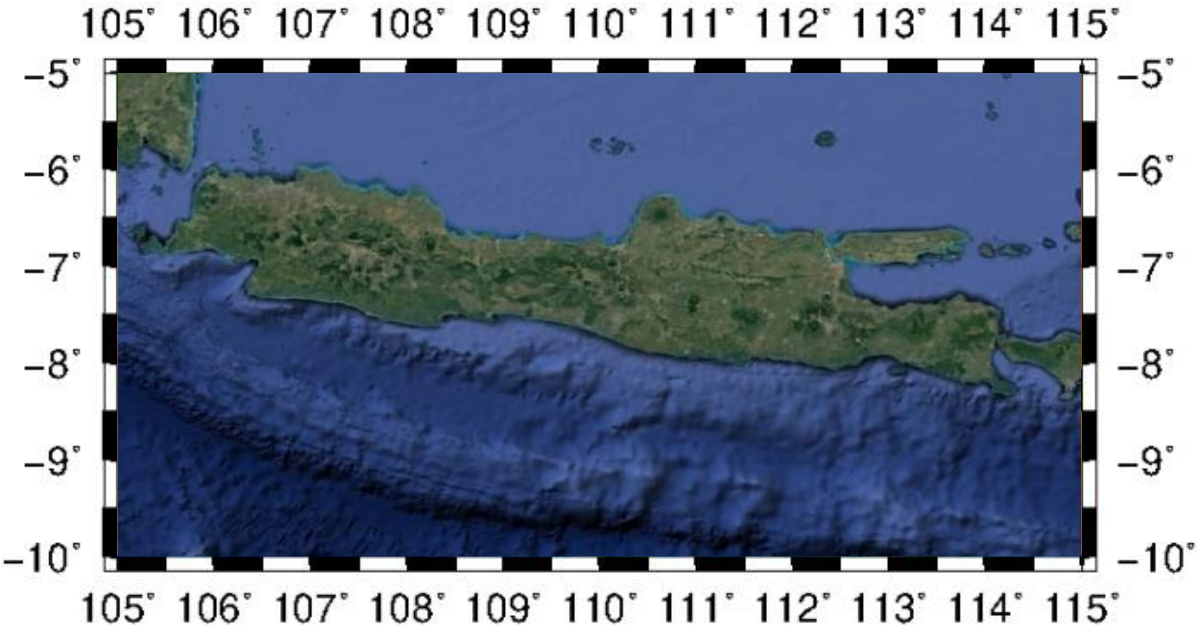

Figure 1. Map of research location

RESULTS

Analysis of Chlorophyll-a and Sea Surface Temperature

The monthly chlorophyll-a and sea surface temperature data utilized in this study were acquired from the NASA Ocean Color website, a widely recognized and trusted platform for satellite-derived oceanographic data. This resource offers extensive datasets that are crucial for examining environmental and marine dynamics. The data acquisition process ensured that the information was both accurate and suitable for the objectives of the study.

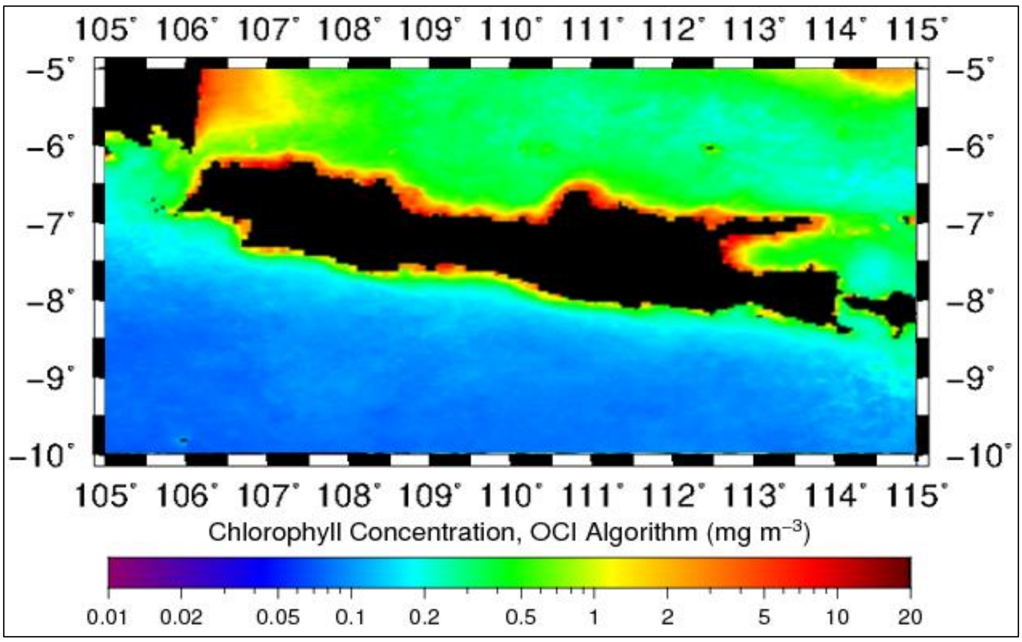

Figure 2. Chlorophyll-a concentration (Chl-a) on Januari 2024

The data processing was conducted using the Sea Data Analysis System (SeaDAS) software, a comprehensive tool designed specifically for the analysis of satellite oceanographic data. SeaDAS provides advanced functionalities, including image correction, data calibration, and visualization, which are essential for extracting meaningful insights from raw satellite observations. The use of SeaDAS software ensures high precision and consistency in handling satellite datasets, which is critical for scientific research.

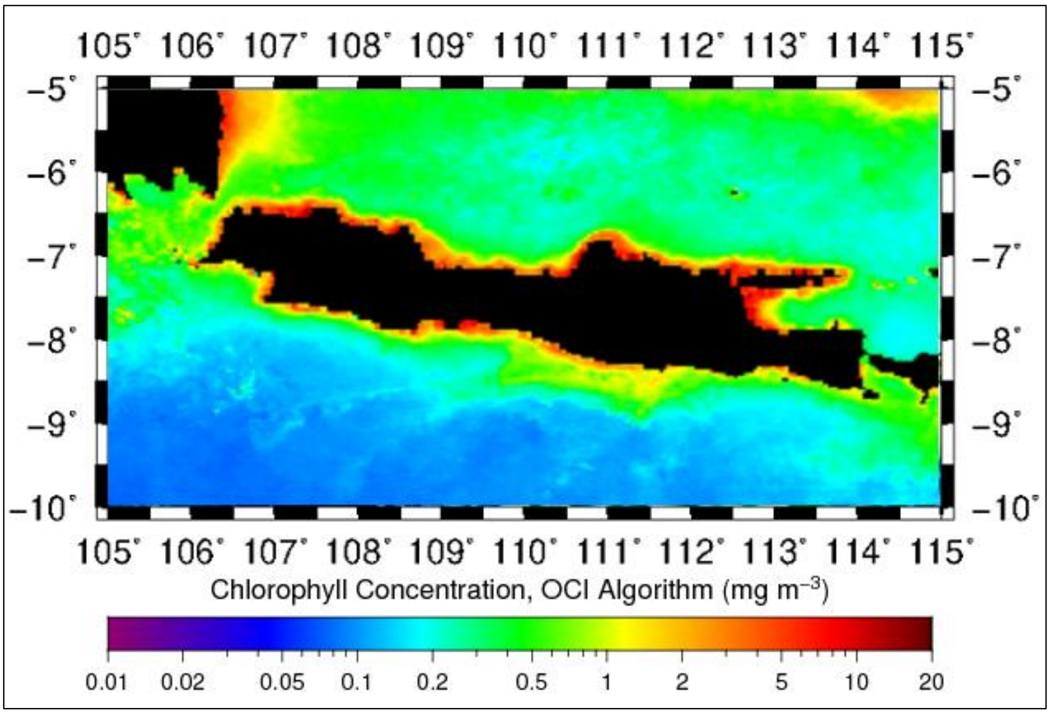

Figure 3. Chlorophyll-a concentration (Chl-a) on Januari 2024

The processing workflow involved several key stages to prepare the data for analysis. A scientific basis to explain the importance of reprojection in geospatial data-based research are from Gao and Mather about digital analysis of remotely sensed imagery and computer processing of remotely-sensed images. The initial stage was the reprojection process, which converted the raw satellite data into a coordinate system aligned with the geographic framework of the study area. This step was essential to ensure that the data was spatially accurate and compatible with other geospatial datasets used in the study. By aligning the data to the correct spatial reference system, potential inaccuracies caused by spatial misalignments were minimized.

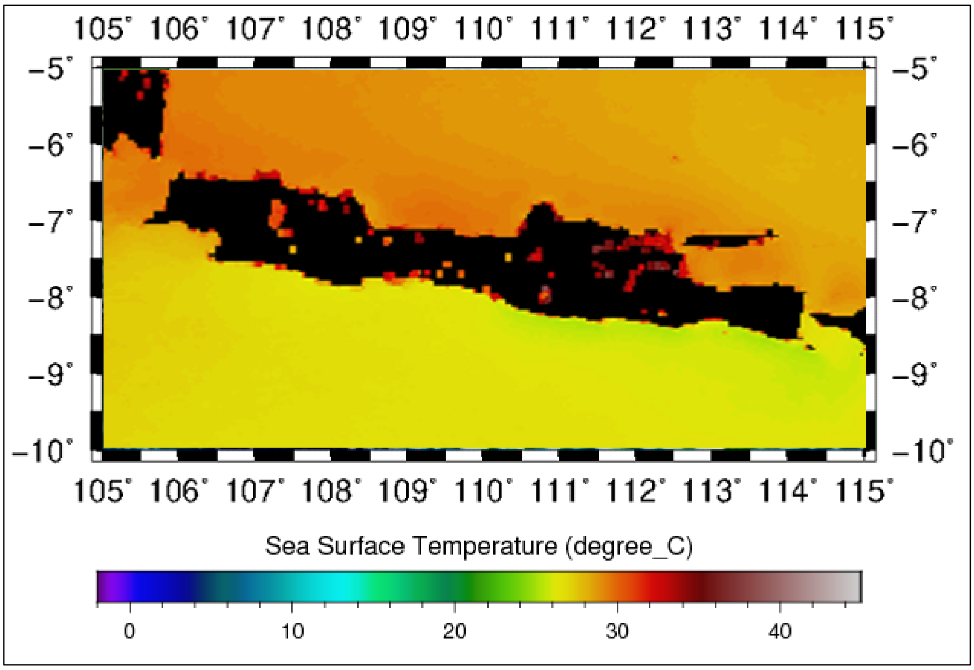

Figure 4. Sea Surface Temperature on January

Following reprojection, area masking was performed to isolate the dataset corresponding to the research location, specifically the southern Java Sea within the WPP-RI 573 region. Area masking involves applying spatial boundaries to filter out extraneous data outside the study area, enabling researchers to focus exclusively on the targeted marine environment. This process not only enhanced computational efficiency but also ensured that the subsequent analyses were relevant to the specific ecological and oceanographic conditions of the study area.

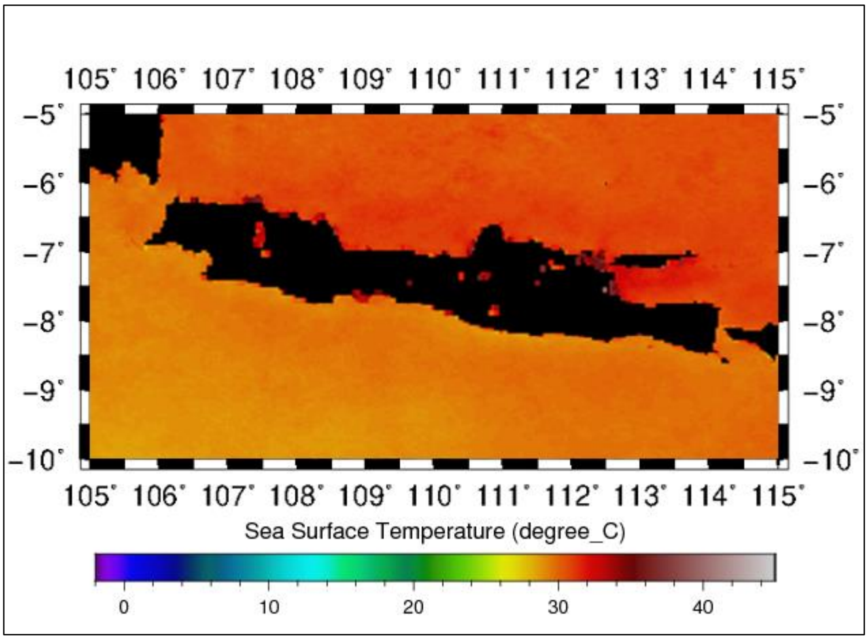

Figure 5. Sea Surface Temperature on December 2024

These preprocessing steps—reprojection and area masking—played a pivotal role in ensuring the accuracy, reliability, and relevance of the data. The refined dataset provided a robust foundation for further quantitative analysis of chlorophyll-a distribution and sea surface temperature patterns. Such detailed data preparation is critical in oceanographic research, as it directly impacts the validity of the results and the overall conclusions drawn from the study. The meticulous processing approach adopted in this research underscores the importance of precision in handling satellite-derived datasets to achieve high-quality scientific outcomes.

DISCUSSION

The monthly chlorophyll-a and sea surface temperature data used in this study were critical for understanding the spatial and temporal dynamics of the southern Java Sea, particularly within the WPP-RI 573 region. By utilizing the NASA Ocean Color database, this research ensured access to high-quality, globally recognized datasets that provided robust insights into the oceanographic conditions of the study area. The selection of these datasets was pivotal, as they represent reliable proxies for assessing primary productivity and thermal variations, which are essential for marine ecosystem analysis. The use of SeaDAS software in processing the satellite-derived data proved to be a highly effective approach. Its advanced features, such as image correction and data calibration, ensured that the datasets were accurately prepared for analysis. Reprojection was a key step in the workflow, as it aligned the satellite data with the geographic framework of the study area. This ensured compatibility with other geospatial datasets and minimized errors that could compromise spatial accuracy. These methodological considerations underline the importance of using appropriate software tools to maintain the precision and consistency of data analysis in oceanographic research.

Area masking was another critical step in the preprocessing workflow, allowing the study to focus exclusively on the southern Java Sea region. This step enhanced computational efficiency by removing extraneous data unrelated to the research objectives. Furthermore, by isolating the target area, the analysis was tailored to the specific ecological and oceanographic characteristics of the WPP-RI 573 region. The importance of area masking in ensuring that data analysis remains relevant to the study objectives cannot be overstated, as it facilitates a focused and accurate interpretation of results.

The refined datasets, prepared through these meticulous preprocessing steps, provided a solid foundation for analyzing chlorophyll-a distribution and sea surface temperature patterns. These parameters are vital indicators of primary productivity and thermal dynamics, which influence marine biodiversity and fisheries productivity. The integration of satellite-derived datasets with advanced processing tools like SeaDAS highlights the potential for remote sensing technologies to support sustainable fisheries management and marine conservation efforts. This research demonstrates that precise data preparation directly impacts the validity of findings and the reliability of conclusions. By employing rigorous methodologies, this study not only advances our understanding of the southern Java Sea's oceanographic conditions but also underscores the broader importance of satellite-derived data in oceanographic research. Future studies should continue to refine these methods, incorporating higher-resolution datasets and longer temporal spans to further enhance the understanding of dynamic marine systems.

CONCLUSION

This study emphasizes the significance of satellite-derived datasets, including chlorophyll-a and sea surface temperature, in analyzing the oceanographic features of the southern Java Sea, particularly within the WPP-RI 573 region. The use of high-quality data from the NASA Ocean Color platform, combined with advanced processing tools like SeaDAS, ensured the analysis was accurate, precise, and relevant. Preprocessing steps, such as reprojection and area masking, were crucial for preparing the dataset for targeted analysis, facilitating a detailed examination of the spatial and temporal dynamics within the study area. The results highlight the vital role of chlorophyll-a as a marker of primary productivity and the influence of sea surface temperature in shaping marine ecosystems, both of which are key to understanding the ecological and fisheries productivity of the region.

This research showcases the importance of remote sensing technologies in aiding marine resource management by providing a robust foundation for evidence-based decision-making. Future research should focus on utilizing higher-resolution datasets and extending temporal coverage to enhance understanding of the complex interactions in marine environments, thereby supporting sustainable fisheries management and conservation efforts in the southern Java Sea and other similar regions.

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