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Fishing Grounds Identification in Jatigede Reservoir Based on Remote Sensing Analysis of Surface Temperature and Chlorophyll-*a*

Heti Herawati[1,*], Zahidah[1], M Candra Wirawan Arief[1], Lantun Paradhita Dewanti[1], Sulastri Prihandini[2]

[1]Department of Fisheries, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Sumedang Regency, West Java, Indonesia
[2]Fisheries Study Program, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Sumedang Regency, West Java, Indonesia

[*]Corresponding Author: h.herawati@unpad.ac.id

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ABSTRACT

Jatigede Reservoir which is located in Sumedang Regency, West Java, serves as a multifunctional site for power generation, irrigation, and fishing activities. The identification of potential fishing grounds within the reservoir relies on key indicators such as chlorophyll-*a* concentration and surface temperature. This study aimed to investigate the spatial distribution of surface temperature and chlorophyll-*a* concentrations in Jatigede Reservoir, using data obtained from Landsat 8 L1 satellite imagery from January to December 2021. The acquired data were processed using ArcGIS, involving the overlay of temperature and chlorophyll-*a* layers for further analysis. The research findings revealed notable variations in surface temperature, with the highest recorded temperature reaching 34°C and the lowest measuring 20°C. Moreover, chlorophyll-*a* concentrations ranged between 0.8 and 2mg/ m^3 in the reservoir. Image processing results indicated that the area below the reservoir exhibited significant potential as an optimal fishing ground. Specifically, three distinct zones were identified as potential fishing grounds during March, September, and December, while four zones were recognized in May, July, and August. In contrast, no potential fishing zones were detected during January, February, April, June, October, and November. This study provides valuable insights into the spatial dynamics of surface temperature and chlorophyll-*a* concentrations in Jatigede Reservoir, facilitating the identification of optimal fishing grounds and aiding in effective resource management strategies for sustainable small-scale fisheries.

INTRODUCTION

Jatigede Reservoir is a multipurpose dam in Sumedang Regency, West Java, Indonesia. This reservoir was built by damming the Cimanuk River, which streamed from Garut to Indramayu Regency in the West Java region. Moreover, it has an abundant water area of about 4,122ha covering a large area of 5 different sub-districts which are: Jatigede, Jatinunggal, Darmaraja, Wado, and Cisitu. This reservoir has several important functions such as hydroelectric power supply, irrigation, and fisheries activities through fishing and aquaculture. Nowadays, the fisheries are one of the most important sectors for their residents. The residents are utilizing fishing to fulfill their food needs and as their new livelihood patterns since they should change their occupation after the inundation process. According to the fishing data from the **Statistics Agency of the Ministry of Fisheries and Marine Affairs (2019)**, the production of Hampla fish (*Hampala macrolepidota)* is about 28,939kg, Patin fish (*Pangasius* sp.) is about 12,706kg, the Nile Mozzambicus is about 15,724kg, Carp (*Cyrprinus carpio)* is about 21,136kg, and the Nile tilapia (*Oreochromus niloticus)* is about 25,939kg. From a development perspective, this reservoir has great potential as a fishing ground; however, the management and utilization of this reservoir are still not optimal **(Putrandy *et al.*, 2021)**.

According to the **The Government of Sumedang regency (2018)**, fisheries activities permitted in the Jatigede Reservoir are restricted to fishing practices that do not have adverse environmental impacts. In contrast, environmental degradation and water quality concerns prohibit aquaculture activities utilizing floating net cages (FNC). The fisheries area within Jatigede Reservoir spans approximately 4,122 hectares and encompasses seven distinct river systems, namely the Cibudah, Cinambo, Cimanuk, Cibayawak, Cihonje, and Cialing Riverlines. These areas have traditionally been utilized by local fishermen as fishing grounds, with their selection of fishing locations based on experiential knowledge rather than formal estimation or analysis. They determine the fishing area by tagging the location with abundant fish resources from previous catches. However, the dynamic nature of water conditions has posed challenges for traditional fishermen, as these conditions largely influence fish movement. Consequently, fishermen face significant limitations in identifying productive fishing grounds, constraining their fishing activities in the reservoir.

The identification of potential fishing grounds is often based on the volume of fish caught by fishermen. Several key indicators, including chlorophyll-*a* concentration and surface water temperature, can be utilized to determine productive fishing areas in aquatic environments. The chlorophyll-*a* concentration, which reflects the water's fertility, indicates the abundance of phytoplankton—a primary food source for herbivorous fish species. **Demena *et al.* (2017)** noted that phytoplankton plays a critical role in the aquatic food chain, producing essential acids during photosynthesis that fish require. High concentrations of chlorophyll-*a* enhance zooplankton productivity, thereby supporting a robust food chain and fostering fish productivity **(Pitchaikani & Lipton, 2016)**.

This study aimed to identify potential fishing ground areas in Jatigede Reservoir by analyzing key parameters such as surface water temperature and chlorophyll-*a* concentration. These parameters are assessed using remote sensing and satellite-based analysis.

MATERIALS AND METHODS

This research was conducted from January to December 2021 in the Jatigede Reservoir area. The study utilized primary and secondary data. The primary data including the chlorophyll-*a* concentration data were taken in the different 6 stations (Fig. 1). While for the secondary data including a one year of surface temperature and chlorophyll-a concentration data in monthly composites, they were obtained from Landsat 8 L1 imagery for the period from January to December 2021. The research location map is shown in Fig. (1).

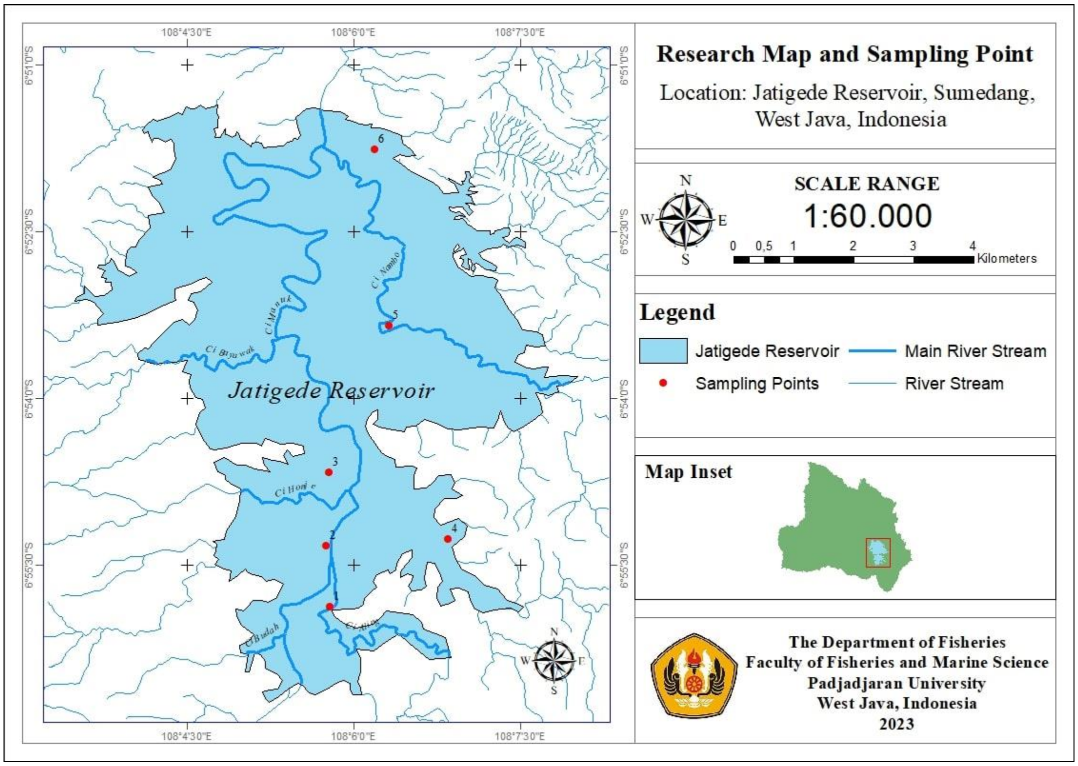

Fig. 1. Research map location

The surface temperature distribution and chlorophyll-*a* were obtained from field observations and then processed using ArcGIS software and were analyzed spatially and temporally. Spatial analysis was carried out visually to determine the distribution of chlorophyll-*a* and surface temperature each month. The distribution of surface temperature and chlorophyll-a was presented as a graph to determine the change in surface temperature and chlorophyll-*a* at a predetermined time.

The initial stage of this research was a literature study and data collection. The image data collected, in the form of water surface temperature and chlorophyll-*a* concentration, were obtained from Landsat 8 L1 images accessed through the website www.usgs.gov. The selection of images used each month was low cloud cover intensity in the study area. The data downloaded were cropped according to the study area before image processing.

Furthermore, this study used the **Pentury (1987)** algorithm to detect chlorophyll-*a* concentrations. Pentury's research applied this algorithm to measure chlorophyll-*a* levels in Ambon Bay, as referenced in **Bashit *et al.* (2019)** and **Rosdianto *et al*. (2021)**.

$$Chl - a = 0.067\left(\frac{B2}{B1}\right) + 0.126$$

Where:

B2 = Landsat 8 OLI + Chanel 1 (Blue Band)

B3 = Landsat 8 Oli + Chanel 2 (Green Band)

The detection of reservoir surface temperature in this study used calculations from **Singh**'s **(2017)** research on land surface temperature in Hoshangabad, India. The stages of temperature detection were as follows:

1. Conversion of digital number (DN) to the top of atmospheric radiance

The formulation used in this step can be seen in Formula 1 below:

$$L_{\lambda} = MLQcal + AL \ldots (1)$$

Information:

L_{λ} = Spectral Radiance ToA

ML = Multiplicative rescaling factor of each band

AL = Additive rescaling factor of each band

Qcal = Digital value

2. Conversion of band radiance to satellite brightness temperature

The formulation used in this step can be seen in Formula 2 below

$$TB = \frac{K2}{In\left(\frac{K1}{L\lambda}+1\right)} - 273{,}15 \ldots (2)$$

Information:

TB = Brightness temperature (^{o}C)

$L\lambda$ = Spectral radiance ToA

K1 = Thermal conversion constant per band

K2 = Thermal conversion constant per band

3. The calculation of NDVI values

The formula used to calculate the NDVI values is provided in Formula 3:

$$\text{NDVI} = \frac{NIR - RED}{NIR + RED} \ldots (3)$$

Information:
NDVI = Normalized difference vegetation index
NIR = Band 5
RED = Band 4

4. The calculation of *P*-values

P-values represent a proportion of the vegetation cover or emissivity. This value is important for adjusting the LST calculation. The formula used to calculate the *P*-values is displayed in Formula 4:

$$\text{Pv} = \left(\frac{NDVI - NDVImin}{NDVImax - NDVImin}\right)^2 \cdots (4)$$

Information:
NDVI = Normalized difference vegetation index
NDVI min = NDVI minimum values
NDVI max = NDVI maximum values

5. The calculation of Emisivitas (E) value

The formula used to calculate the E- values is presented in Formula 5:

$$\text{E} = 0{,}004 + \text{Pv} + 0{,}986 \ldots (5)$$

Information:
Pv = *P*-values

6. Conversion of satellite temperature to land surface temperature (LST)

The formula used to calculate the LST is presented in Formula 6:

$$\text{LST} = \frac{TSensor}{1 + w\left(\frac{\lambda Tsensor}{\rho}\right) \times In(\epsilon)} \ldots (6)$$

Information:
LST = Land surface temperature (in Kelvin).
λ = Wavelength of emitted radiance (in meters).

ρ = h·c/σ: A constant involving Planck's constant (h), speed of light (c), and Boltzmann constant (σ).

ϵ = Surface emissivity.

RESULTS AND DISCUSSION

1. Surface temperature distribution

The distribution of water surface temperature in Jatigede Reservoir in each month of the year can be seen in Fig. (2). The optimal temperature range for sustaining aquatic life in tropical waters is approximately 28– 32°C. Within a temperature range of 18–25°C, fish can survive, albeit with a noticeable decline in appetite. Temperatures between 12– 18°C risk fish health, while temperatures below 12°C are fatal for tropical fish due to cold stress **(Pasha *et al.*, 2015)**. Sudden increases in water temperature significantly impact the metabolic rates of fish, resulting in elevated oxygen demands compared to cooler water conditions **(Alfonso *et al.*, 2021)**.

An analysis of surface water temperatures in the Jatigede Reservoir from January to December 2021 revealed variations in temperature distribution. These data offer valuable insights into surface temperature patterns. Spatial analysis identified significant temperature anomalies in certain months, which were likely influenced by incomplete cloud cover removal in the satellite imagery. Cloud cover can distort spatial data processing, leading to inaccuracies in image interpretation. This observation aligns with the research of **Laksitaningrum *et al.* (2017)**, which attributes such anomalies to climatological factors, including rainfall, with their impact on reservoir systems.

Overall, the surface water temperatures in the Jatigede Reservoir ranged from 20 to 34°C during 2021. From January to August, temperatures were relatively stable, fluctuating between 20 and 26°C. Variations in surface temperatures are attributed to differences in the inflow characteristics of the seven river catchment areas feeding into the reservoir. Additionally, anthropogenic activities, both within and around the reservoir, likely contribute to the observed spatial and temporal variations in water temperature **(Hamzah *et al.*, 2016)**.

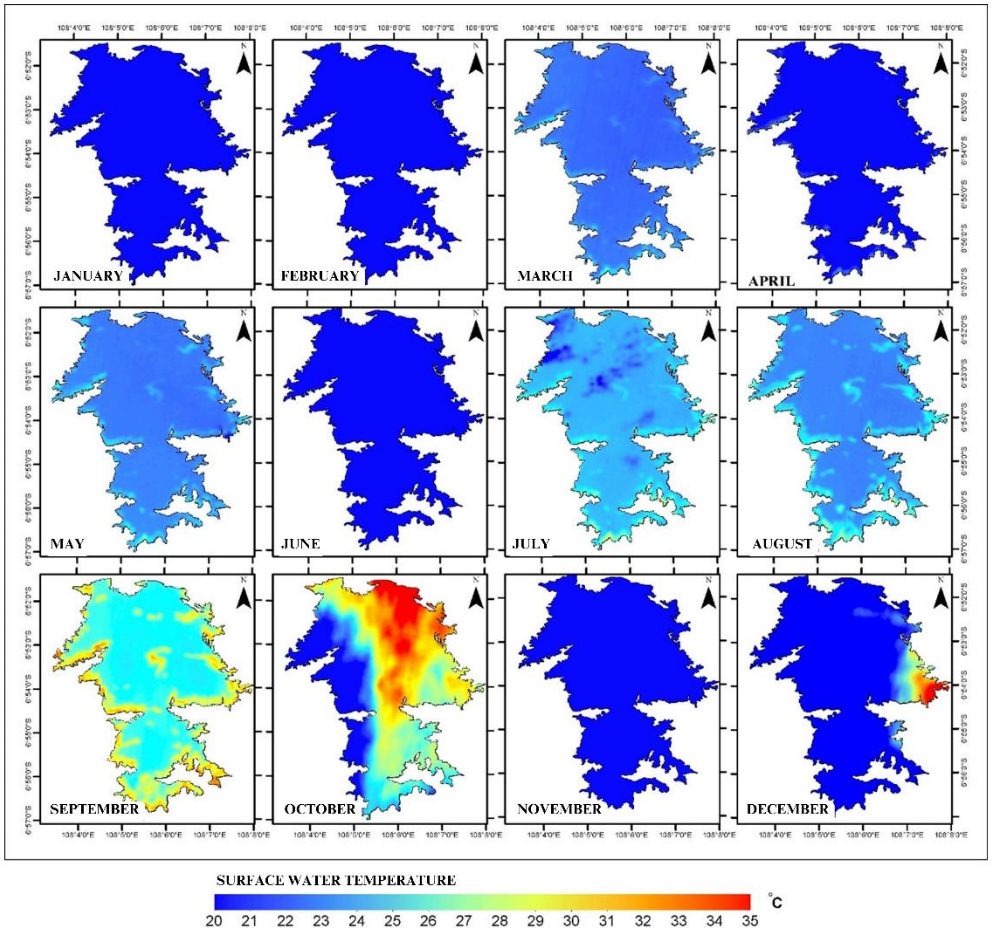

Fig. 2. Surface water temperature distribution

2. Chlorophyll-*a* distribution

Phytoplankton plays a crucial role in the food chain of aquatic ecosystems. As primary producers, they determine the presence of other organisms in the ecosystem. According to **Nur *et al.* (2021)**, higher water fertility positively impacts both phytoplankton and fish populations. Therefore, analyzing chlorophyll-*a* distribution is essential for mapping fishing grounds in such water bodies. The spatial distribution of chlorophyll-*a* in the Jatigede Reservoir is shown in Fig. (3).

The Jatigede Reservoir is fed by several river catchment areas, where nutrient-rich water flows from upstream to the estuary through river runoff. Higher chlorophyll-*a* values are influenced by factors such as temperature and sunlight exposure, with increased sunlight often leading to higher chlorophyll-*a* levels. This is consistent with the findings of **Arifelia *et al*. (2017)** regarding the factors that affect chlorophyll-*a* distribution. Spatial data reveal that chlorophyll-*a* concentrations vary month to month. In February, October, November, and December, chlorophyll-*a* concentrations are consistently high across the water, ranging from 1.5 to 2mg/ m³. However, in January, March, July, and September, chlorophyll-*a* concentrations are lower in the central part of the water, with values around 0.8mg/ m³.

High chlorophyll-*a* concentrations can indicate excessive water fertility. The nutrient content, particularly nitrates and phosphates dissolved in the water, influences this. **Nurdin *et al.* (2023)** explained that elevated chlorophyll-*a* concentrations are typically found in waters with high nutrient levels. Based on the spatial data from this study, high concentrations of chlorophyll-*a* are generally located in areas close to the mainland. These areas are affected by ammonia and nitrate levels from both local and surrounding communities' waste. Sunlight exposure also plays a role in chlorophyll-*a* concentrations, with high irradiation leading to increased levels. This aligns with the findings of **Arifelia *et al*. (2017)**, who noted that factors such as high sunlight and river areas contribute to elevated chlorophyll-*a* concentrations.

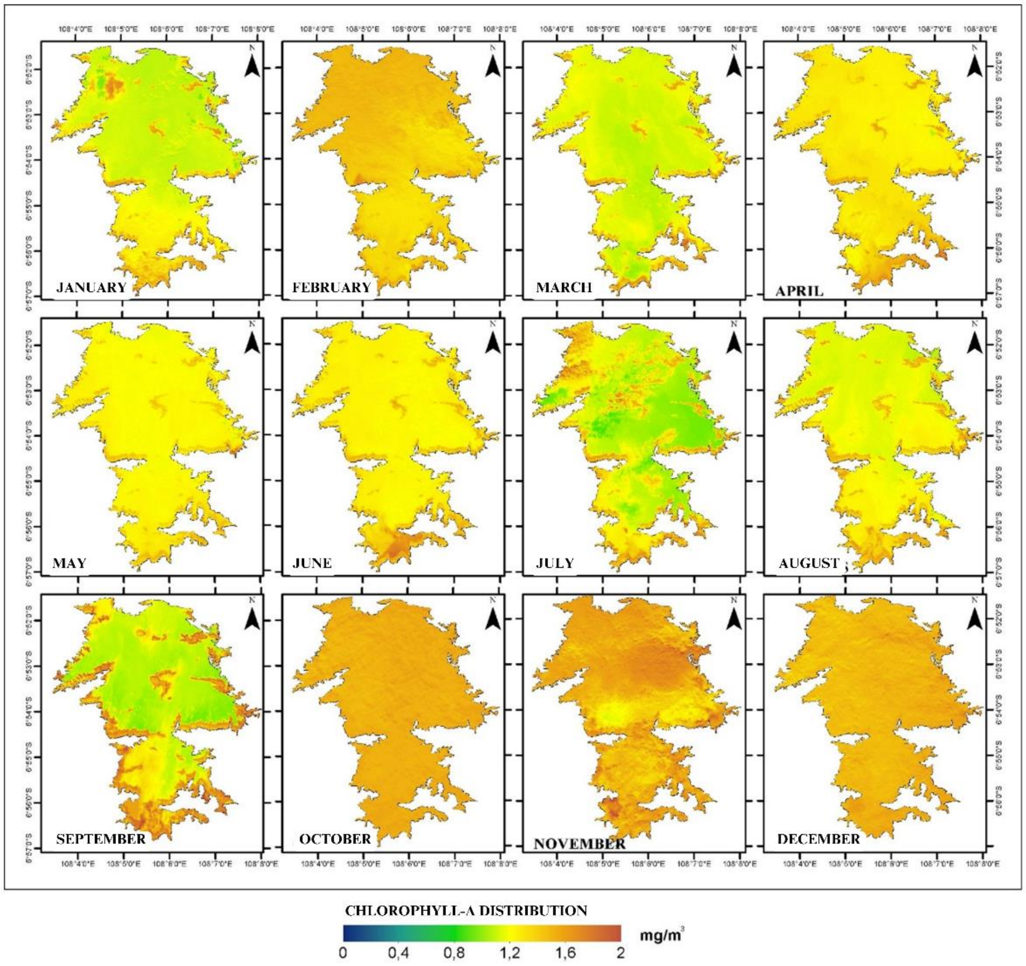

Fig. 3. Chlorophyll-*a* distribution

3. Fishing zones determination

The potential fishing zones in Jatigede Reservoir are shown in Fig. (4). Based on the results of spatial image data processing, three potential fishing zones were identified in March, September, and December 2021. These zones are located in the Cisitu, Darmaraja, and Wado sub-districts. In May, July, and August, four potential fishing zones were observed, including the Cisitu, Darmaraja, West Darmaraja, and Wado sub-districts. No potential fishing zones were identified in January, February, April, June, October, or November 2021, as the surface temperature during these months did not meet the minimum required for potential fishing zones. According to **Mursyidin *et al.* (2015)**, potential fishing zones are characterized by chlorophyll-*a* concentrations greater than 0.5 mg/m³ and surface temperatures ranging from 26 to 30°C. The Cimanuk watershed, located at the bottom of the reservoir, has high chlorophyll-*a* concentrations and surface temperatures, making it a high-potential fishing zone in the Jatigede Reservoir.

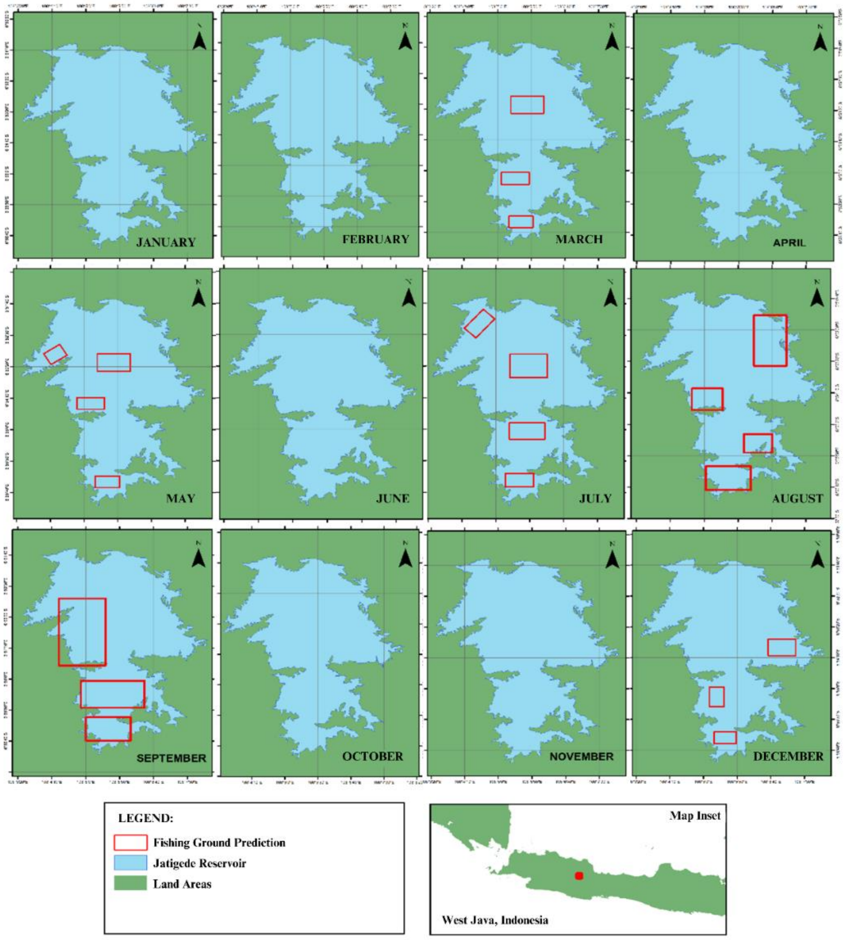

Fig. 4. Fishing ground mapping in Jatigede Reservoir

CONCLUSION

The surface temperature distribution in the Jatigede Reservoir in 2021 ranged from 20 to 34°C, with the most suitable surface temperatures found in the Cimanuk River basin. The distribution of chlorophyll-*a* in the reservoir strongly supports the potential of fisheries located at the bottom. High chlorophyll-*a* concentrations were observed in February, October, November, and December, with values reaching 2mg/ m³.

Based on the prediction results, three potential fishing zones were identified in the Jatigede Reservoir in March, September, and December 2021. In May, July, and August 2021, four potential fishing zones were identified due to high chlorophyll-*a* concentrations and optimal surface temperatures. However, no potential fishing zones were detected in January, February, April, June, October, and November 2021, as the surface temperatures in those months did not meet the minimum requirements for potential fishing zones.

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