

## MAPPING OF CURRENTS AND TIDES FOR ANALYSIS OF LOCATION SUITABILITY AND EFFECTIVENESS OF PORT ACTIVITIES, TANJUNG WANGI PORT

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Submitted: February 8, 2025 Accepted: July 20, 2025

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### ABSTRACT

Banyuwangi Regency has 282 km of coastline with high coastal potential to be developed, such as tourism, fisheries, and ports. This study aimed to analyze the suitability of the Tanjung Wangi Port location based on tidal and ocean current data. Tidal data were obtained from the Indonesian Hydrographic Data Center (IHDC), and ocean current data were obtained from AVISO Satellite Altimetry. The data were processed using Microsoft Excel and ArcGIS using the inverse distance weighted (IDW) method to create ocean current maps. The results showed that Tanjung Wangi Port has a double-dominant mixed tidal type. The highest water level was recorded at 5.207 m, and the lowest water level was 0.809 m, with a Mean Sea Level (MSL) of 3.048 m. The sea current speed ranged from 0.023 m/s to 1.414 m/s from the Southeast and Southwest Indian Ocean, with the direction of the sea current towards the Banyuwangi Regency. Stable tidal conditions and low ocean currents make the Tanjung Wangi Port ideal for safe harbor and navigation activities and contribute positively to the effectiveness of port activities. Further research should involve direct field surveys and seasonal variability analyses to improve the accuracy of port planning.

Keywords: Current, Tidal, Port, Banyuwangi.

### INTRODUCTION

Banyuwangi Regency, East Java Province is one of the areas with extensive coastal areas. The length of the coastline in the Banyuwangi Regency is 282 km, one of the longest in Indonesia. Coastal areas have high and complex natural resources that can be developed for spatial utilization, such as tourism, fisheries, and ports (Hidayati & Rahman, 2022). The position of the Banyuwangi Regency is also strategic because it directly faces the Bali Strait and the Indonesian Ocean. However, shipping accessibility in the Banyuwangi Regency is an obstacle, and it has not been able to maximize its existing potential (Tandi 2023).

Ports are the main supporting infrastructure for sea transportation to serve the mobility of goods and people in the archipelago. Port development is needed to maximize the enormous potential in the water sector, such as in the Banyuwangi Regency. Tidal and ocean current data are required to support the development of the port.

Tides are a phenomenon of periodic movement of the rise and fall of sea level position based on the period or factors that influence it (Gading, 2020). Tidal data were used to approximate the lowest and highest water surface elevations. This information is useful for predicting the depth of shipping lanes, dock placement, and the location of breakwaters. Sustained tides can also cause siltation due to the sedimentation of materials brought by the tides into

the harbor. Port activities can operate smoothly if the average water level is 1.8 m. However, if the tides are extreme, they can hamper port activities; therefore, it is important to consider them in port planning.

Currents are water dynamics that influence changes in coastal and marine areas. Water movement causes horizontal and vertical displacement of water masses (Lukman, 2020). Ocean currents play an important role in port development. Ocean current data can provide more precise accuracy for erecting buildings on the coast (Nastarina et al., 2023). This is because ocean currents can significantly influence the stability of coastal buildings, public buildings, and settlements around the coast.

Optimal port development requires not only an analysis of tides and ocean currents but also consideration of environmental impacts. The development of large infrastructure, such as ports, can significantly impact coastal ecosystems, increasing erosion and threatening the balance of the ecosystem. Therefore, environmental assessment is essential in port development planning to minimize the negative impacts.

With accurate tidal and ocean current data, the location suitability of Tanjung Wangi Port and its relationship to the effectiveness of activities at the port can be analyzed. The use of these data also allows for more precise planning related to the

location of docks, breakwaters, and shipping lanes, and optimization of the potential waters of the Banyuwangi Regency.

Based on this description, this study is expected to provide useful information and become the basis for analyzing the suitability of the Tanjung Wangi Port location and assessing the effectiveness of port activities based on tidal and ocean current data.

## MATERIAL AND METHODS

### Research Location

This study was conducted at Tanjung Wangi Port, Banyuwangi Regency, East Java Province. Geographically, the Banyuwangi Regency is located at 7°45'15"-8°43'2" N-S and 113°38'10" East. Administratively, the north of Banyuwangi Regency is bordered by Situbondo Regency, the east is bordered by the Bali Strait, the west is bordered by Bondowoso Regency and Jember Regency, and the south is bordered by the Indian Ocean. The research locations are illustrated in Figure 1.

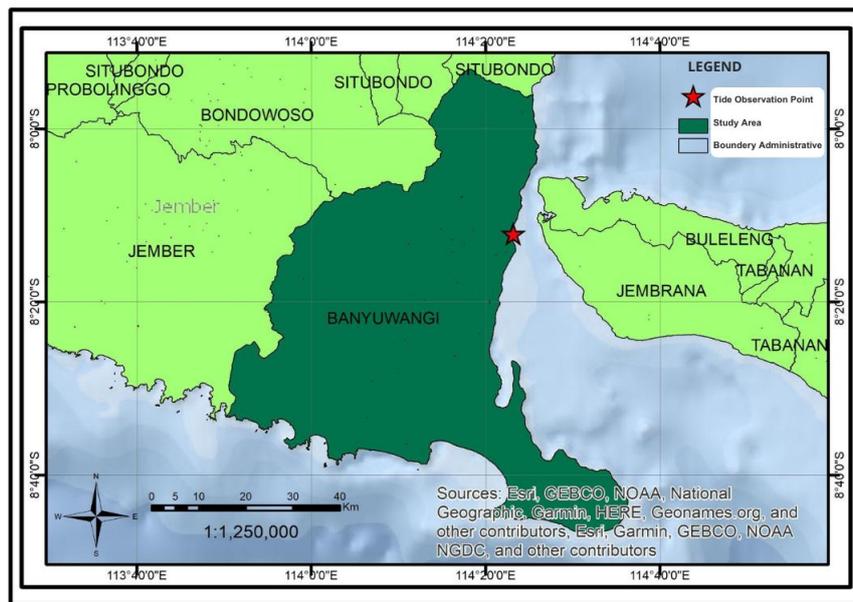


Figure 1. Map of study location.

### Research Tools and Materials

Secondary data were also utilized in this study. Secondary data were recorded from August 16 to September 15, 2024, in the form of tidal data obtained from the Indonesian Hydrographic Data Center (IHDC), and ocean current data obtained from AVISO Satellite Altimetry Data. After data collection, data processing was performed using Microsoft Excel and ArcGIS.

### Observation Parameters

#### Formzahl Numbers

To determine the type of tides in a body of water, the Formzahl number is calculated using the following formula:

$$F = \frac{\Delta H_{tide}}{\Delta H_{lowtide}}$$

Where:

F = Formzahl Number

$\Delta H_{tide}$  = The difference in the height of the water surface at high tide in one period

$\Delta H_{lowtide}$  = The difference in the height of the water surface at low tide in one period

#### Estimated Sea Level

To calculate the Mean Sea Level (MSL) from tidal data, the centerline of the water level fluctuation was estimated using the following formula:

$$MSL = \frac{Highest\ tide + Lowest\ Tidel}{2}$$

Where:

MSL = Mean sea level value

Highest tide = Highest tide value

Lowest Tide = Lowest tide value

#### Ocean Current Speed and Direction

To create a map of the speed and direction of ocean currents, it is necessary to know the values of the meridian component (V) and zonal component (U) in advance. The meridian (V) and zonal (U) components were determined from the data

downloaded from AVISO and calculated using the following formula:

$$Speed = \sqrt{(U + V)^2}$$

$$Directions = Tan^{-1} \left( \frac{V}{U} \right)$$

Where:

U = Zonal component

V = Meridian component

### Data Analysis Technique

The data analysis techniques used in this study were descriptive and quantitative analyses using mathematical equations from previous studies. The data obtained were then calculated using the current and velocity formulas to create ocean current maps using the Inverse Distance Weighted (IDW) method. Furthermore, tidal data obtained from the Indonesian Hydrographic Data Center (IHDC) were converted into graphs to create tidal maps.

### Flow Chart

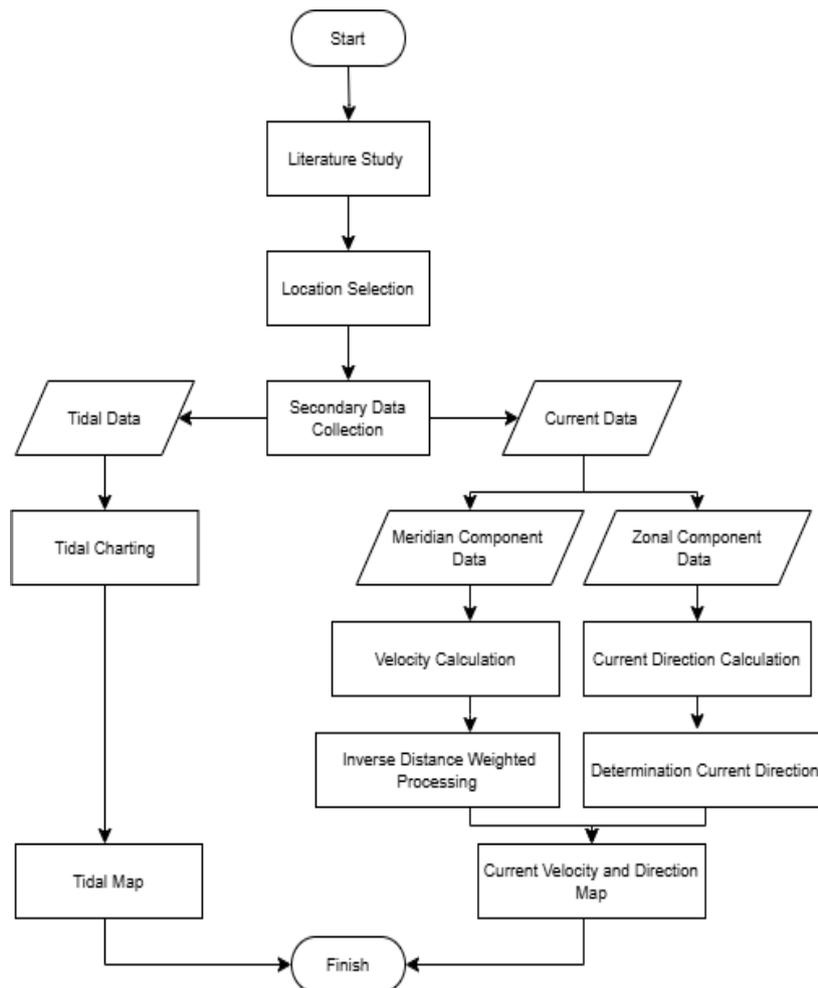


Figure 2. Research Flow Chart

RESULTS AND DISCUSSION

Tidal Port of Tanjung Wangi Banyuwangi Regency

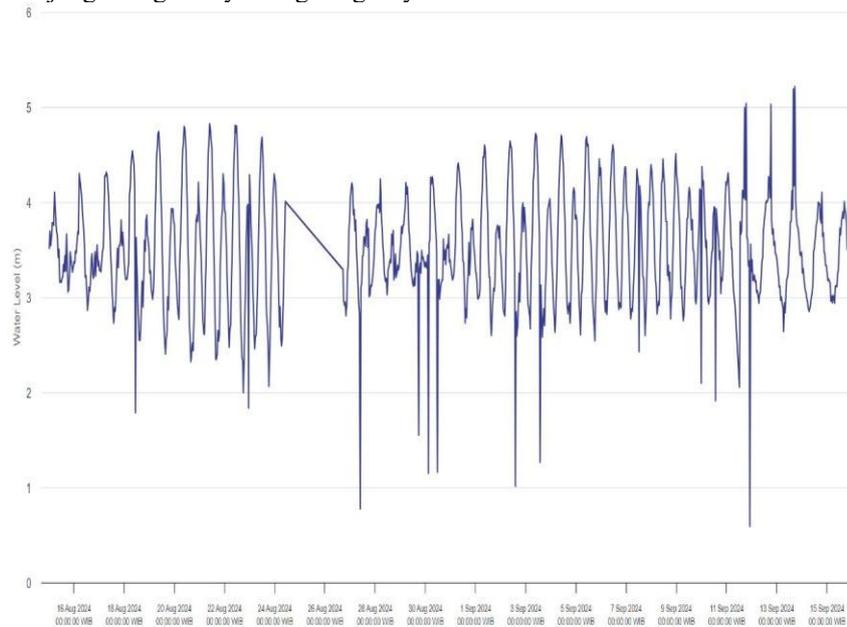


Figure 3. Tidal Height Chart

The tidal results for the period of August 16–September 15, 2024, at Tanjung Wangi Harbor, Banyuwangi Regency, showed a Formzahl number of 0.2315 obtained from the tidal harmonic component analysis. This value indicates that the tidal type at Tanjung Wangi Harbor is a double dominant mixture. This is characterized by the

presence of two high and low tides in one day (24 h) during a tidal recording period of one month. Based on Figure 3, the highest water level value was recorded at 5.207439 m on September 13, 2024, at 18:14, whereas the lowest water level value of 0.890129 m was recorded on September 9, 2024, at 05:23. Thus, a Mean Sea Level (MSL) value of 3.048784 m was obtained.

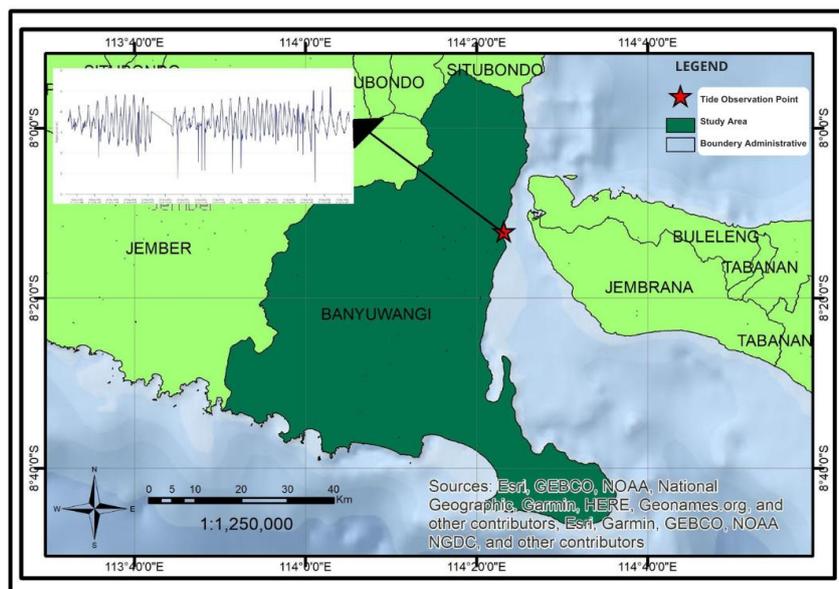


Figure 4. Tidal map of Tanjung Wangi Harbor Wangi Port, Banyuwangi Regency.

The tidal-type map of Tanjung Wangi Harbor is shown in Figure 4. This map displays a graph of the

tides at the research site, which shows two high tides and two low tides per day. This indicates that

the tidal type at Tanjung Wangi Harbor was double dominant.

### Ocean Current Direction

The processing of ocean current data using latitude and longitude coordinates, as well as the value of

the meridian and zonal components on a specific date, produced a map of the direction of ocean currents in the Tanjung Wangi Port area. The speed of the ocean current direction was in the range of the lowest value of 0.0233525 m/s and the highest value of 1.41421 m/s.

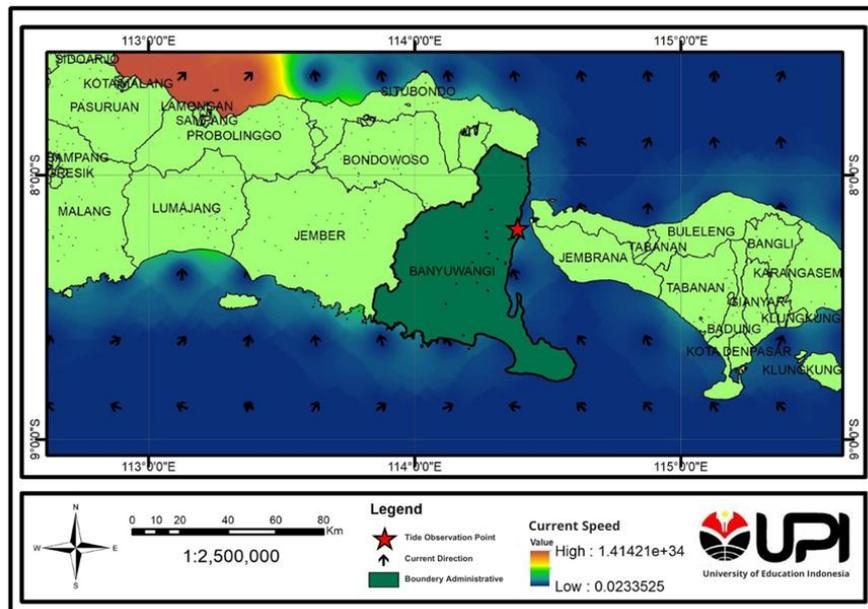


Figure 5. Tidal Sea current direction map of Tanjung Wangi Harbor, Banyuwangi Regency.

In Figure 5, the direction of the ocean currents is represented by arrows, and the speed of the ocean currents is represented by blue for the lowest value and red for the highest value. Ocean currents in the Banyuwangi area are shown with green to blue gradations; the closer to blue, the ocean currents are categorized into the low category. The ocean currents towards the Banyuwangi Regency originate from the Southeast and Southwest, the Indian Ocean.

### Utilization of Tidal and Ocean Current Maps for Location Suitability and Effectiveness of Port Activities

Tidal and ocean current data are important for assessing port location suitability. Tanjung Wangi Harbor has stable tides with a double dominant mixed type. Under these conditions, Tanjung Wangi Harbor has sufficient depth at low tide so that ships, especially large ships, can enter and exit safely. Tidal mapping can also be used as a reference for planning loading and unloading schedules, ideally carried out during high tides. With stable tides, safe navigation in Tanjung Wangi Harbor can be ensured, as it is not affected by extreme tidal fluctuations.

The coastal area around Tanjung Wangi Port has a low current speed, which is ideal for reducing the risk of ship accidents and making it easier for ships to maneuver. In addition, the low current speed helps reduce sediment accumulation; therefore, there is no need for dredging during the maintenance process. With low currents, Tanjung Wangi Harbor avoided the influence of extreme weather events, such as storms.

Tidal and ocean current data are key factors in determining an appropriate and safe harbor location. Tanjung Wangi Harbor exhibits very favorable characteristics with stable tides and adequate depth for vessels, as well as low currents that support navigation safety and reduce the risk of accidents. The existence of these conditions not only supports smooth operations but also reduces the need for intensive maintenance work. Thus, the establishment of the Tanjung Wangi Port in Banyuwangi Regency is considered suitable because it has the potential to become an efficient and sustainable port and make a positive contribution to the effectiveness of port activities in the surrounding areas. In addition to evaluating its suitability, tidal and current data can be useful for

port maintenance planning, development planning around the port, disaster mitigation, jetty placement, and determining the location of breakwaters.

## CONCLUSION

As an area located in the easternmost part of Java Island, the Banyuwangi Regency depends on seaports to support marine activities and transportation. The seaport area functions as a means of sea transportation, which determines the effectiveness of interisland crossing activities.

During the one-month recording period, the Banyuwangi Regency had a double dominant mixed tidal type with two tides in one day, as indicated by the Formzahl number of 0.2315, obtained from the tidal harmonic component analysis. The highest water level value was recorded on September 13, 2024, at 18:14, with a value of 5.207439 m, and the lowest water level value of 0.890129 m occurred on September 9, 2024, at 05:23. Thus, the MSL value was 3.048784 m.

The Tanjung Wangi Port area has a sea current direction originating from the Southeast and Southwest, the Indian Ocean towards the Banyuwangi Regency. The lowest and highest sea current speeds were 0.0233525 m/s and 1.41421 m/s, respectively.

Tidal and ocean current data are key factors in determining the locations of the right and safe ports. With stable tides and low currents, the establishment of the Tanjung Wangi Port location in the Banyuwangi Regency is considered suitable because it has the potential to become an efficient and sustainable port and make a positive contribution to the effectiveness of port activities in the surrounding area. In addition to evaluating its

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suitability, tidal and current data can also be useful for port maintenance planning, development planning around the port, disaster mitigation, dock placement, and determining the location of the breakwaters.

Future research should include field surveys and direct measurements to obtain more accurate results. In addition, we analyzed the seasonal variability of currents and tides to understand the changes that occur throughout the year. This is important for effective port planning and anticipating changes in sea conditions.

## ACKNOWLEDGMENT

We would like to express our sincere gratitude to all those who contributed to the writing of the paper entitled "Mapping of Seawater Currents and Tides for Analysis of Location Suitability and Effectiveness of Port Activities". Without the dedication and collaboration of various parties, this study would not have been completed properly or on time.

We thank Dinda, Lia, Lutfiah, Mirna, and Vanya for their dedication and contributions to the writing team, who worked hard to formulate and compile this paper with great care. The contribution of each team member was invaluable in producing an in-depth analysis of the suitability and effectiveness of ports in the Banyuwangi Regency. Thank you for inviting us to grow in a better direction.

Hopefully, this paper will not only contribute to the scientific literature but also be a source of inspiration for effective and maximally functional infrastructure development efforts, especially in the Indonesian archipelago. We thank all those involved in the writing of this paper.

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