# Understanding Climate Characteristics, Impacts, and Mitigation Strategies in Indonesian FisheriesManagement Zone

**Silviatuszuhro Firdaus**

**Summary**

*The utilisation of fisheries management in Indonesian waters is divided into 11 areas known as WPPNRI (Fisheries Management Areas of The Republic of Indonesia). One of the areas, called WPPNRI 572, encompasses the waters of the Western Indian Ocean, Sumatra, and the Sunda Strait. In the WPPNRI 572 area, wind speeds range from 1 to 7 m/s during JJA (June, July, and August). This wind pattern significantly influences wave heights in this area, which can reach 1.5 to 2 metres.*

*One mitigation measure to prevent accidents caused by high waves is the modelling and forecasting of marine weather. This effort aims to assess climate trends, characteristics, and risks related to waves, winds, and cyclones. Additionally, awareness campaigns and training sessions can be organised for fishermen, seafarers, and coastal communities to educate them on responding to high waves and storms, including safe evacuation procedures.*

## Introduction

The government has divided Indonesia's territory into territorial waters and exclusive economic zones (Zona Ekonomi Eksklusif/-ZEE), resulting in the creation of 11 Fisheries Management Areas of The Republic of Indonesia (Wilayah Pengelolaan Perikanan Negara Republik Indonesia/WPPNRI). WPPNRI 572 encompasses the waters of the Western Indian Ocean, Sumatra, and the Sunda Strait. The WPPNRI 572 area borders directly on the Western Indian Ocean, which causes high waves to occur in this area frequently. Climate change also has a significant influence on extreme weather patterns, causing an increase in the incidence and severity of hydrometeorological disasters such as floods, landslides, and coastal erosion and an increase in the incidence of tropical cyclones. As a result, WPPNRI 572 is very vulnerable to disasters, causing populations, livelihoods, and ecosystems to become susceptible.

Understanding weather and sea wave data is crucial for fishermen to prevent fishing accidents and for planning transportation routes and tourism activities. Analysing wind, climate patterns, and the influence of tropical cyclones on high waves in Indonesian waters is of significant importance for early warning systems and effective decision-making in disaster prevention and mitigation.

The research emphasises the likelihood of marine disasters due to high waves and suggests adaptations to minimise the associated risks.

In this study, wind and Significant Wave Height (SWH) data from 1979 to 2020 (42 years) were utilised. The data was sourced from ERA5 to determine the distribution of wind speed and SWH in various Indonesian waters and visualise the results. Subsequently, a comparison and literature review were conducted to strengthen the analysis performed.

## Climate and Weather Condition in WPPNRI 572 Zone

In Indonesia, the east monsoon (June, July, and August, commonly referred to as JJA) brings dry air masses due to winds blowing southeast from Australia, resulting in a dry period. In contrast, the west monsoon (December, January, and February, known as DJF) is characterised by winds blowing from the northwest, namely from Asia, bringing moist air and causing the rainy season in Indonesia. During the southeast monsoon (JJA), stronger winds from the Australian region affect the southern part of the Indonesian seas and generate higher waves (Wirasatriya et al., 2021).

In the west monsoon season (DJF), the dominant wind direction is from the northern waters of Indonesia to the northeast, reaching speeds of 4 to 8 m/s, as depicted in Figure 1a. During the southeast monsoon (JJA), wind speed over inner and southern Indonesia seas reaches its peak during JJA with a magnitude of 7 to 10 m/s (Figure 1c).

During the transitional season periods, namely MAM (May, April, and May) and SON (September, October, and November), wind speeds throughout WPPNRI weaken and change direction. During the MAM period, the wind speed is only 2 to 5 m/s (Figure 1b), and during the SON period, the wind speed is 3 to 6 m/s (Figure 1d), and these impact the wave height (Figure 2b and Figure 2d). These periods differ greatly from the JJA and DJF periods, where wind speeds reached 4 to 10 m/s.

The WPPNRI 572 area experiences high wind speeds ranging from 1 to 7 m/s during the JJA season. These wind patterns also affect the significant waves in the area, which can reach heights of 1.5 to 2 metres. Additionally, WPPNRI 572 encounters higher wind and wave speeds compared to other Indonesian waters due to its location, influenced by the Indian Ocean. The Indian Ocean Dipole Mode (IODM) positively strengthens wind speeds in the Java Sea and the West Sumatera Sea during the East season (JJA) (Rachmayani et al., 2018).

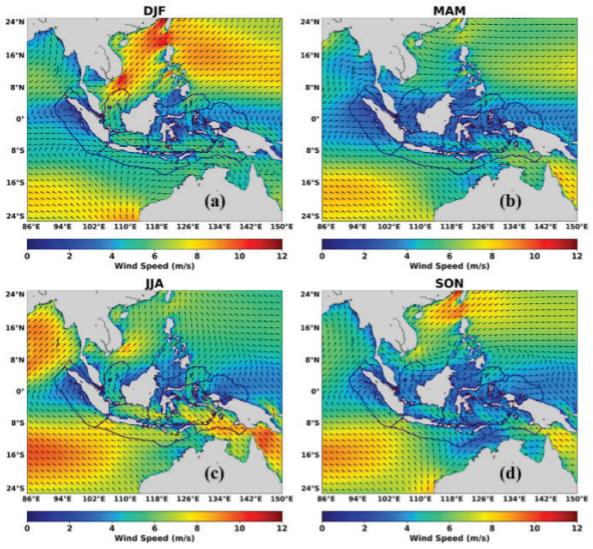


Figure 1. Seasonal average of wind fields for (a) DJF, (b) MAM, (c) JJA, and (d) SON
Source: Ningsih et al., 2023

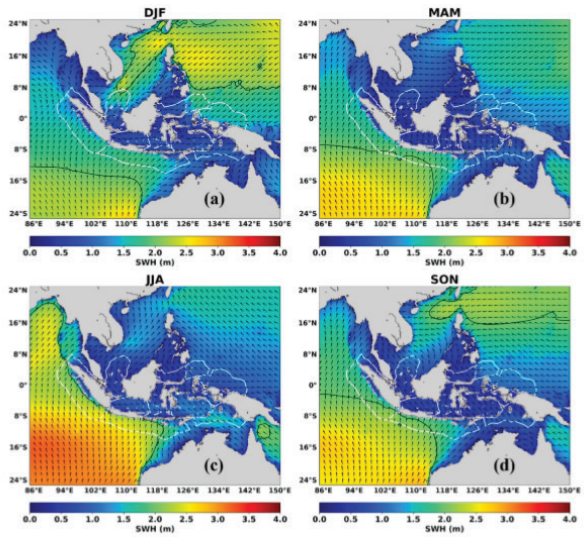


Figure 2. As in Fig. 3, but for SWH distribution during (a) DJF, (b) MAM, (c) JJA, and (d) SON. The contour line represents SWH.
Source: Ningsih et al., 2023

**Notable Climate Disaster at the WPPNRI 572 Zone**

At the WPPNRI 572 location, the probability of a wave exceeding 2 metres in height is 8.67% in the DJF season and significantly higher at 56.30% during the JJA season (Ningsih et al., 2023). Besides being influenced by the open sea, the significant wave heights exceeding the average in Indonesian waters in WPPNRI 572 is due to the formation of tropical cyclones. Some tropical cyclones that have occurred in this area include Tropical Cyclone Durga in 2008 in the Southwest Waters of Bengkulu, Tropical Cyclone Anggrek in 2010 in the West Sumatra Waters and Tropical Cyclone Bakung in 2014 in the Southwest Waters of Sumatra. Cyclones Cempaka and Dahlia in 2017 were also formed in the waters of Lampung and crossed the southern waters of Java. (Rahman, 2017). These tropical cyclones have resulted in an increase in sea wave height in the waters of the western Mentawai Islands, Bengkulu, southern waters of East Java, Enggano Island, western waters of Lampung, the southern part of the Sunda Strait, the waters off the southern coast of Banten to Central Java, and the western Indian Ocean from Lampung to the south of Java (Chairunnisa, 2017).

**Climate Risk Impact and its Mitigation Plan**

High waves have a significant impact on fishing activities, maritime transportation, and several tourist destinations. For instance, during the occurrence of cyclones Cempaka and Dahlia in 2017, the usual SWH in Krakatau Island (Lampung), which typically measures 0.42 metres, surged to 2.70 metres. Similarly, on Panaitan Island (Banten), where the average SWH is normally 0.65 metres, rose to 3.46 metres (Windupranata et al., 2018). These extreme wave conditions led to the temporary suspension of fishing activities and tourism due to the extremely risky conditions. In addition to their impact on fishing, transportation, and tourism activities, high waves can also disrupt industrial activities in coastal areas, affecting operations at power plants and ports.

Understanding the significant risks posed by high waves to coastal areas and several sectors, it is important to establish well-structured mitigation plans. This plan combines various strategies to strengthen coastal resilience and minimise the adverse impacts of high-wave events. Several things can be done to minimise the impact of high-wave events, namely:

- Modelling and forecasting regarding ocean weather to determine climate trends and the characteristics of waves, winds, and cyclones are very necessary for mitigating marine accidents due to high waves.
- Strengthening the policies and regulations used in sea transportation is very necessary.
- Building and regularly maintaining safe harbour facilities and breakwaters can protect boats and ships when high waves occur.
- Restoring mangrove forests and creating coastal green belts can be used as natural protection. Mangroves are natural barriers that can reduce wave energy and protect coastal areas from erosion.
- Conduct public awareness campaigns and provide training to fishermen, mariners, and coastal communities about how to respond to high waves and storms, including safe evacuation procedures.
- Implementation from the authorities, government, local communities, and residents also plays an important role in mitigating and managing this disaster.

**Conclusion and Recommendation**

In the west monsoon season (DJF) in Indonesia, the dominant wind direction is from the northern waters of Indonesia to the northeast, reaching speeds of 4 to 8 m/s. During the southeast monsoon (JJA) in the opposite direction, blowing from southeast to northwest, wind speed over inner and southern Indonesia seas reaches its peak during JJA with a magnitude of 7 to 10 m/s. In the WPPNRI 572 area, there is a high wind speed of between 1 to 7 m/s in the JJA season. This also has an impact on the size of the waves that occur in the area, which can reach 1.5 to 2 m in height. This is influenced by its location directly facing the ocean and several tropical cyclones that occur. If a tropical cyclone occurs, the significant wave can increase to five times higher.

Ultimately, knowledge about the characteristics of waves and tropical cyclones is necessary for disaster mitigation. Marine weather modelling and forecasting, which aims to assess climate trends, characteristics, and risks of waves, winds, and cyclones, can be carried out by institutions such as BMKG and BNPB. This effort serves to reduce the risk of maritime accidents due to high waves. Information regarding when high waves and strong winds occur can be communicated effectively to fishermen and tourism site managers, thereby ensuring their understanding. Additionally, awareness campaigns and training sessions can be organised for fishermen, sailors, and coastal communities to educate them on responding to high waves and storms, including safe evacuation procedures.

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**Author**
**Silviatuszuhro Firdaus**
Bandung Institute of Technology

**Supervisor**
**Arief Rizky Herdiansyah**
Policy Advocacy and Community Empowerment (PACE) Deputy Programme Officer
Resilience Development Initiative

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