Wind Pattern Analysis and Its Impact on Flight Safety at Fatmawati Soekarno Airport Using Wind Rose Method (2019-2023)

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Abstract *– A study of wind patterns was conducted to minimize aircraft accidents at Fatmawati Soekarno Airport, Bengkulu City. The data was then processed using the Wrplot application to show the direction and difference in wind speed and create a wind pattern image in the form of a wind rose diagram. This study aims to analyze wind patterns and speeds at Fatmawati Soekarno Airport, Bengkulu City for a period of 5 years (2019-2023) using the Wind Rose method. Data obtained from the Meteorology, Climatology, and Geophysics Agency, Fatmawati Bengkulu Meteorology Station shows that the dominant wind direction comes from the Southeast, Northeast, and North which are influenced by seasonal changes. The results of the analysis show extreme wind speeds ranging from 2.50 - 4.70 m / s which are classified as light winds and are still safe for flight operations. With a deep understanding of this wind pattern, it is hoped that airport managers can optimize the use of runways and improve flight safety by accommodating weather conditions. The results of this study also emphasize the importance of consistent wind pattern monitoring to support risk management related to extreme weather.*

Keywords*: Wind Pattern; Fatmawati Soekarno Airport; Wind Rose Method*

INTRODUCTION

Bengkulu City is the capital of Bengkulu Province, located on the west coast of Sumatra Island, precisely across the Indian Ocean, which has many natural and cultural riches that are still not widely known, such as tourism (Indasari & Yanto, 2022). Air transportation becomes an unavoidable choice, Apart from its diverse choices, air transportation has the advantages of high speed, modern technology, optimal service and safety standards (Amanah, 2023). Fatmawati Soekarno Airport is one of the major airports in the Sumatra region which is influenced by the geographical conditions and climate of the surrounding ocean (Azir, 2024).

Weather is one of the main factors that can affect flight performance and safety. One of the weather parameters that must be considered is wind (Gede Yamuna Ceswaraningrat et al., 2024). Wind is the movement of large amounts of air caused by the rotation of the earth and differences in air pressure around it. Wind moves from areas of high pressure to areas of low pressure. Factors that cause wind include wind pressure, wind speed, and wind movement time (Rawal et al., 2023). Wind direction is the direction the wind blows, expressed in degrees measured clockwise from the north point of the earth or simply measured according to the compass angle scale. Conversely, wind speed is the speed of horizontal air movement influenced by local pressure gradients, local altitude, and local topography and expressed in units (knots or m/s) (Hidayat et al., 2023). Wind speed is important because it is uncertain in any situation and is constantly changing, So you

can use monthly average wind speed and direction data to identify wind movement patterns (Simbolon et al., 2022).

Surface winds that change direction and speed can affect flight safety and efficiency such as increasing growth in all sectors, including the tourism sector (Zany & Utri, 2022). Along with the increasing number of airplane passengers (Silvia et al., 2021). The airport must provide additional flights to serve all passengers. The air side of Fatmawati Soekarno Airport, including the runway, has a major influence in maximizing flight routes. In this case, flight activity has three phases: takeoff, cruising, and landing. One of the weather factors that affects these three phases is wind (Teknik, 2023).

The software used to identify wind patterns is the Wrplot View display (Wattimena & Salamena, 2022). This is a program that analyzes the wind data obtained and produces wind speed seen from the compass direction in the form of a wind rose (Qothrunada et al., 2022). A Wind Rose is a graphical device that depicts the direction and speed of wind patterns over a period of time at a location (Prasetiyo, 2024). And eight wind instructions as a guideline for determining the direction of the wind (Gunasti et al., 2024). The compass rose diagram is very important in representing meteorological data, especially in wind research, because the compass rose represents the frequency and proportion of wind events in each wind direction (Suryana, 2022).

Wrplot View is a weather data program. This software provides wind rose display, frequency analysis, and graphs of various weather data formats. The Wrplot application is an excellent alternative for analyzing wind direction and speed data, especially in airport runway development. The wind diagram shows the proportion of wind events with a certain speed from various directions during the recording period (Sitohang & Pahlevi, 2023). The purpose of this study was to analyze wind patterns and speeds in the Fatmawati Airport area, Bengkulu City over a period of five years (2019-2023) and identify seasonal wind patterns. The results of this study are expected to contribute to airport management and support regional flight safety.

RESEARCH METHOD

The wind rose method is used to display the distribution of wind direction and speed so that compared to other methods, the wind rose is more intuitive for understanding wind patterns in a certain period. The wind data used in this study were obtained from BMKG data, Fatmawati Soekarno Bengkulu Meteorological Station in the form of monthly averages over a period of five years (2019-2023). Wind data processing was carried out using Wrplot View software which produces seasonal wind direction and extreme wind speed output representing Bengkulu City from the cardinal directions. Wind direction and speed data are processed by classifying the direction into 8 cardinal directions, namely North, Northeast, East, Southeast, South, Southwest, West, Northwest. While the wind direction speed is classified into 6 classes, namely 0.50-2.10 m/s, 2.10-3.60 m/s, 3.60-5.70 m/s, 5.70-8.80 m/s, 8.80-11.10 m/s, and more than or equal to 11.10 m/s. To make it easier, a distribution table of wind direction and speed is made. After that, a wind rose diagram is made to support the analysis, including a wind rose graph of the wind speed that occurs.

RESULTS AND DISCUSSION

Based on the research results, the analysis carried out is an analysis of the monthly average on wind patterns at Fatmawati Soekarno Airport in 2019-2023

showing extreme wind speeds. Compared to previous research conducted at Syarif Kasim II Airport, Pekanbaru, high wind speeds representing Bengkulu City in the range of 2.50-4.70 m/s, are a type of gentle wind that is still considered risky for flights, but it should be understood that this wind pattern allows airport managers to optimize runway utilization and improve risk management related to extreme weather.

Results

Monthly analysis was conducted from January to December, covering the period 2019 to 2023 and includes monthly averages for that year with the most extreme wind speeds representing the Bengkulu City area, observations must be made using the international standard scale, namely the Beaufort wind scale, as shown in table 1.

Table 1. Wind Strength according to the Beaufort Scale.

Beaufort Scale	Wind Speed m/s	Pattern Description	Information
0	0,0-0,2	Calm	Vertical smoke column
1	0,3-0,5	Ligth air	Tilted smoke column
2	1,6-3,3	Ligth breeze	The leaves are moving
3	3,4-5.4	Gentle breeze	The branches move
4	5,5-7,9	Moderate breeze	The branches are moving
5	8,0-10,7	Fresh breeze	Tree trunk moving
6	10,8-13,8	Strong breeze	Big tree trunk moving

Source: Sujitno.1978

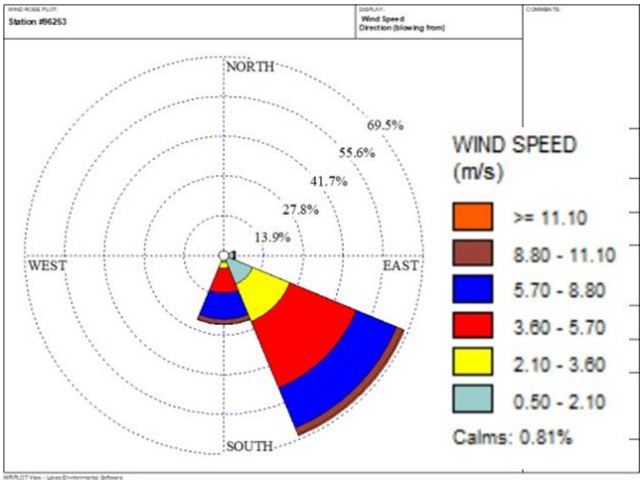

Figure 1. Surface Wind October 2019

In Figure 1, it can be seen that in October the main dominant wind comes from the Southeast with a percentage of 69.5%, winds from the Southeast often accompany the dominance of easterly winds, especially in tropical areas affected by the dry season. The dominance of this wind direction shows a stable and strong pattern without any significant fluctuations in other directions. Winds from the South with a percentage of 41.7% which are a type of gentle wind and have the highest speed compared to other months and have a frequency of strong winds with a range of 5.70–8.80 m/s (blue) which is quite significant especially from the Southeast, high wind speeds in the range of 8.80–11.10 m/s (brown) are more visible and low wind speeds of 0.50-2.10 m/s, strengthening the characteristics of the wind that is active throughout the month. October is the most extreme month in 2019 representing the Bengkulu City area. This is because in October it has an average wind speed of 4.70

m/s which is the highest speed compared to other months and has a frequency of strong winds with a range of >8.80 m/s even >11.10 m/s (extreme) which is significantly represented in the dominant direction and seasonal patterns that support the transition period towards the Asian Monsoon which usually produces strong winds in the region, especially those coming from the Southeast.

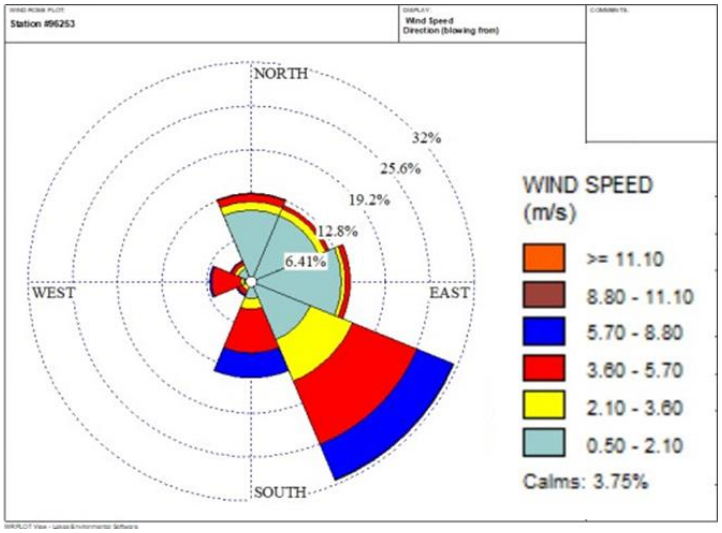

Figure 2. Surface Wind September 2020

In Figure 2. It can be seen that in September 2020 the dominant wind came from the Southeast with a percentage of 32%, winds with high speeds of ≥5.70 m/s came more often from the Southeast than other directions. Seasonal winds in this month are a transition from the dry season to the rainy season which often triggers an increase in wind speed. Winds from the Southeast are quite significant, especially in the Bengkulu City area. This month is at the end of the dry season (Southeast Season), where this season brings winds from Australia which often reach their peak before weakening in October so that winds from the Southeast can be stronger due to the difference in atmospheric pressure between the southern hemisphere (Australia) and the Indian Ocean. Extreme wind speeds show strong winds of ≥5.70 m/s (blue to brown) which are also distributed in several directions such as from the Northeast and East which are types of moderate winds.

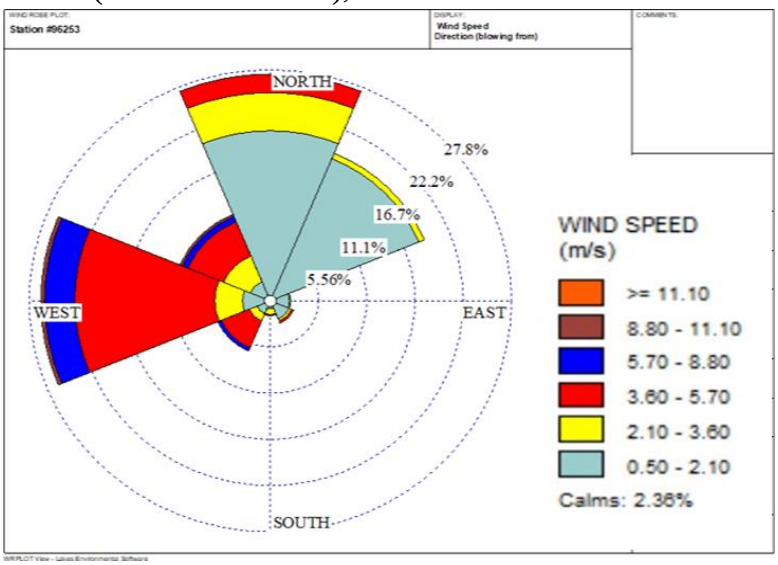

Figure 3. Surface Wind November 2021

Figure 3 shows that in November the dominant wind direction comes from the North which has a percentage of 27.8%, this shows that this area has a wind pattern that blows more often. Wind speeds from the North have the majority in the low to moderate category, winds in the range of <2.10 m / s (light blue) that dominate the area reflect a gentle breeze or calm conditions. Winds with a speed of 2.10-3.60 m / s with a gentle breeze type show the most dominant direction and occur quite often, especially from the North. While in calm conditions, winds with a speed of 2.36% show that most of the time this area has an active wind flow although often in the low speed category. So that the direction and speed of this wind greatly affect flight operations, especially in terms of fuel efficiency, travel time, and safety. Winds with low speeds are not too dangerous for flights, but it is necessary to be aware of the presence of shear winds at low altitudes during landing or take off. The impact of takeoff such as headwinds, wind blowing from the front of the aircraft during takeoff and landing helps increase lift, so that the aircraft requires a shorter runway distance. With the dominant wind from the North, the airport in that location must adjust the runway direction so that the plane faces the wind. However, the wind from the North can accelerate the speed of the plane flying in the same direction as the wind, thus shortening the flight time.

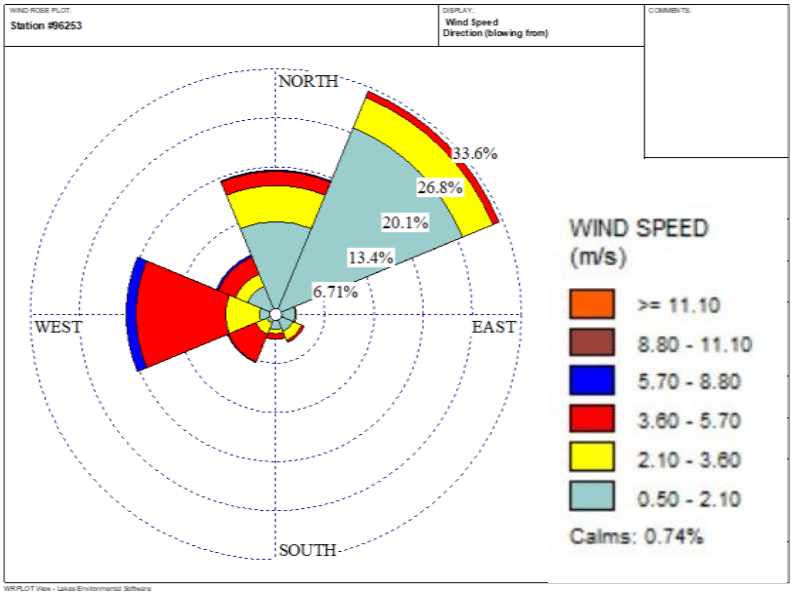

Figure 4. Surface Wind February 2022

Figure 4 shows that in February 2022, the wind direction is more dominant from the Northeast, this wind is the dominant wind that plays a significant role especially for seasonal patterns, so that when viewed from wind speed, the Northeast direction has a fairly large contribution compared to other directions. However, when viewed in totality from the wind frequency, the North direction is stronger with a percentage of 33.6%. February has the highest wind speed and is considered extreme representing Bengkulu City. Although the average speed of 2.50 m/s (Ligth breeze) is still classified as low to moderate and does not reach the strong wind category, this wind speed is still within the safe range for flight operational activities.

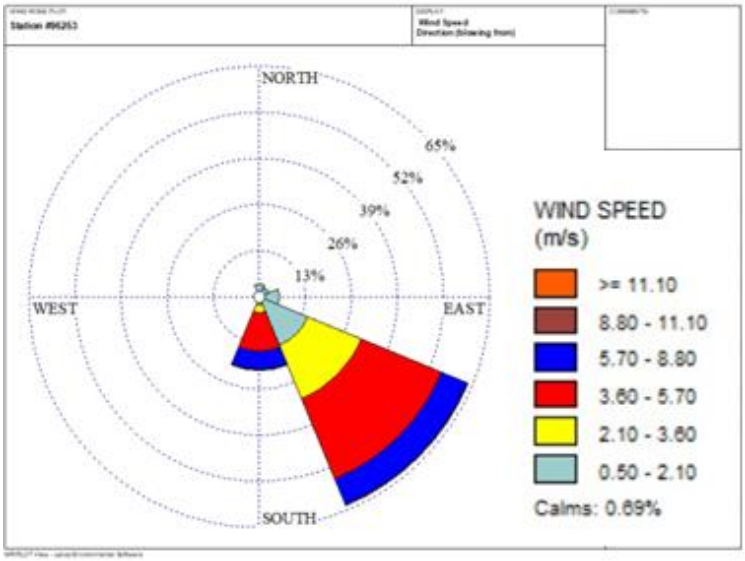

Figure 5. Surface Wind September 2023

Figure 5 shows that in September 2023 the dominant wind came from the Southeast with the largest percentage contribution of 65%, this month is included in the end of the dry season. During this season, the monsoon winds from Australia (Southeast Monsoon) are very dominant. The Southeast Monsoon occurs due to the difference in air pressure between Australia (which is cold and high pressure) and Southeast Asia (which is warmer and low pressure). Other directions with quite significant contributions come from the South, which is 52% and from the East almost does not show significant wind movement. Meanwhile, the dominant wind speed this month is in the range of 3.60-5.70 m / s (red) is a type of light wind with moderate wind indications which are also quite significant but the wind speed is above 11.10 m / s (orange) have almost no wind speed so there is no indication of strong winds. Wind speeds higher than the average of 3.56 m / s remain in calm conditions and consistent wind direction which reduces the risk of turbulence during takeoff.

CONCLUSION

Based on the explanation, the extreme winds representing Bengkulu City in the five-year period (2019-2023) are from the Southeast, Northeast, and North. The wind direction blowing from the Southeast and Northeast is related to the seasonal pattern. The Southeast Monsoon occurs in the dry season when dry air blows from the Australian mainland, while the Northeast Monsoon occurs in the rainy season when low pressure draws wind from the North, so that the monsoon wind pattern greatly influences the direction and speed of the wind and has different speeds, especially at certain times of the year. This wind rose shows how the direction and speed of wind at an airport can affect aircraft operations, especially in terms of safety during takeoff and landing. High wind speeds representing Bengkulu City in the range of 2.50-4.70 m/s, is a type of gentle breeze that is still considered risky for flights, but it should be understood that this wind pattern allows airport managers to optimize runway utilization and improve risk management related to extreme weather.

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