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Analysis of Surface Wind Speed at Sultan Thaha Jambi Airport for The Period 2019-2023 using The Windrose Method

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Abstract: This study aims to analyze the direction and speed of surface winds at Sultan Thaha Airport in Jambi at an altitude of 10 meters during the period 2019–2023 using the wind rose analysis using WRPLOT View software. Wind direction and speed are meteorological parameters that significantly impact flight safety and operational efficiency, particularly during takeoff and landing phases. This study is motivated by the importance of understanding wind patterns in supporting technical decision-making by airport authorities, such as determining runway direction and issuing early warnings about hazardous crosswinds. The data used in this study are secondary data sourced from the Jambi BMKG Climatology Station, which include daily wind direction and speed parameters and were processed using WRPLOT View software. The results show that the dominant wind direction changes seasonally, from northwest in January–March to southeast in May–September, influenced by monsoon winds. The average wind speed ranges from 8.6 to 9.3 knots, with a maximum speed of 29.16 knots recorded on September 6, 2019. Therefore, the research results can support the improvement of aviation operational safety, particularly in decision-making regarding runway direction and aircraft maneuvering strategies.

Keywords: surface wind, wind direction and speed, windrose method, Sultan Thaha Airport Jambi, aviation safety

1. Introduction

Indonesia is an archipelagic country with more sea than land. Located in Southeast Asia and straddling the equator, it lies between the continents of Asia and Australia and the oceans of the Indian and Pacific Oceans. Astronomically, it is located between the latitudes of 07° 20' N and 14°S and the longitudes of 92° E and 141° E [1]. The Indonesian islands are connected by various modes of transportation, including air, sea, and land. Due to its high population density, efficient transportation infrastructure is essential for quickly connecting the islands, making air transportation the primary and most widely used option [2]. Sultan Thaha Airport is an international airport located in the Paal Merah area of South Jambi District, Jambi City. Sultan

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Thaha Airport plays a pivotal role in facilitating regional connectivity and fostering local economic development. Given its role as the primary entry point to the region, the airport's operations are significantly influenced by stable and predictable meteorological conditions.

Air transportation is subject to stringent safety standards aimed at achieving a zero accident rate. Even the most minuscule error has the potential to have lethal consequences for flight safety, endangering the well-being of both the crew and passengers. The establishment of safety standards in the aviation industry is subject to international regulation by the International Civil Aviation Organization (ICAO). Factors influencing flight safety include ground control personnel, air control, and weather (meteorology). In the domain of aviation, the flight path is typically divided into three distinct phases: take-off, cruising, and landing. A meteorological aspect that impacts all three phases is wind. The landing phase is considered the most hazardous phase of flight due to the aircraft's proximity to the ground and its decrease in altitude [3].

Aviation safety standards are influenced by many factors, including aircraft condition, ground and air traffic controller performance, and weather conditions. One weather factor that greatly affects aviation is surface wind speed. Wind speed can impact various aspects of airport operations, including take-off and landing procedures, as well as the use of equipment and facilities [4]. Strong or unstable winds can cause delays, route changes, or even flight cancellations, ultimately impacting the efficiency and safety of airport operations. There are three wind patterns in airport flights: headwind, tailwind, and crosswind, as shown in Figure 1 .

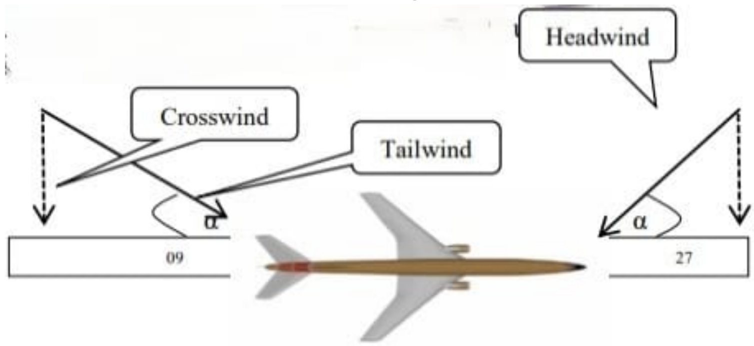


Figure 1. Headwind, Tailwind, and Crosswind

Based on Figure 1, a headwind is defined as a wind that blows from the front of an aircraft. Given the tendency of headwinds to augment lift, it is customary for pilots to elect to initiate landing and takeoff procedures when confronted with such atmospheric conditions. This configuration enables the aircraft to maneuver in the direction of the wind, thereby reducing the distance required for takeoff or landing. A tailwind is a wind that blows from behind the aircraft, which can reduce lift. The majority of aircraft will avoid taking off and landing in conditions of tailwind. However, tailwinds are often selected during the aircraft's cruising phase due to their capacity to accelerate the aircraft's forward motion, thereby conserving time and fuel. However, when encountering a tailwind, the volume of air entering the engine is reduced, which can lead to a decrease in engine performance. Additionally, the aircraft may be affected by side winds, which can further compound the challenges posed by the tailwind. A crosswind is defined as a wind that blows from the side of an aircraft. Significant changes in crosswind speed during landing can cause the aircraft to veer off the runway or even skid. Crosswinds represent a particularly salient threat, given their potential to compromise the safety of small aircraft during landing procedures. In the event that the aircraft encounters crosswinds, the pilot must have a strategy to maintain balance to prevent the aircraft from tilting left or right, ensuring safe flight on the runway. High-speed crosswinds have the potential to have fatal consequences for aircraft during takeoff and landing, such as a runway overrun or an aircraft landing with excessive crosswinds, which can result in the aircraft exiting the runway .

Wind is the movement of air near the Earth's surface, moving from areas of high air pressure to areas of low air pressure. Wind has two important characteristics, namely direction and speed, which are formed due to differences in air pressure in various areas . It is these pressure differences that cause wind to move, with the direction of the wind depending on the position of the high and low pressure areas. Wind speed is also influenced by the magnitude of the pressure difference between the two areas [5]. Wind speed is a measure of how quickly air moves horizontally. Factors influencing wind speed include air pressure differences, altitude, and surface conditions [6]. Generally, winds blow from east to west. This occurs because the Earth's rotation produces what is known as the Coriolis effect. The Coriolis effect plays a significant role in determining wind direction on Earth. As the Earth rotates on its axis, winds moving over the surface experience a deflection from their straight path due to the Coriolis effect. In the Northern Hemisphere, the Coriolis effect causes winds moving in a straight line to be deflected to the right , while in the Southern Hemisphere, winds moving in a straight line are deflected to the left (Herman. The Coriolis effect can be calculated using the equation:

$$F_c = -2\,\Omega\,V\sin\phi = -fV \qquad (1)$$

Wind is a vector quantity expressed in two-way frequency distributions, namely direction and speed. Wind direction is the direction from which the wind current blows or from which the wind blows and is expressed in degrees determined by the direction of the rotation of the clock hand and starting from the north point of the earth, in other words according to the compass point [2]. Wind speed is the distance traveled by air or air flow expressed in kilometers per hour or meters per second (m/s) or knots.

The factors that cause wind include, first, the barometric gradient, a number that indicates the difference in air pressure between two isobars that are 111,322 km apart. The greater the barometric gradient, the stronger the wind blows. Second, the location of the place where the wind speed near the equator is faster than that far from the equator. Third, the height of the place where the higher a place is, the stronger the wind blows, this is caused by the influence of friction that inhibits the speed of air. The higher a place is, the smaller the friction force. Fourth, during the day the wind will blow stronger than at night.

The Coriolis effect is the deflection of wind moving along the Earth's surface to the right of the direction of motion in the northern hemisphere , and to the left in the southern hemisphere . The Coriolis effect is caused by the Earth's rotation and its response to the direction of rotation of the rotating water mass, causing water to rotate counterclockwise in the northern hemisphere and clockwise in the southern hemisphere [7]. Surface wind is one of the meteorological elements whose direction and speed are easily changed and varied. The greater the roughness of a region's surface, the more it will hinder the direction and speed of the wind [2]. The measuring instrument used to measure or determine wind speed is an anemometer. The types of anemometers commonly used are cup anemometers and vane anemometers. The device used to indicate wind direction is a wind vane [8]. An anemometer works by capturing the wind blowing against its propellers. When the propellers rotate, this movement is converted into measurable numerical values. The propellers function as sensors that detect wind gusts. As it rotates, the propeller moves a device that measures wind speed based on the rotation that occurs [9].

Wind occurs due to differences in air pressure or temperature within a region. These differences are influenced by the amount of solar heat received by the Earth's surface . Regions that receive more solar heat tend to have higher air temperatures and lower air pressure. The temperature and pressure differences between areas with different amounts of heat cause airflow, creating wind. The conditions of this airflow are also influenced by the Earth's surface over which it passes and by surface temperature differences. The process of wind formation can be described as follows: First, differences in atmospheric density cause horizontal variations in air pressure. Second, temperature differences in subtropical regions generate the energy needed to maintain wind speed despite obstacles. Third, th e Earth's rotation deflects winds toward the equator in the Northern Hemisphere , causing them to move clockwise . Meanwhile, winds move counterclockwise in the Southern Hemisphere. Wind speed, or wind wave velocity, is an important atmospheric measure. Wind speed occurs when air moves from high-pressure areas to low-pressure areas, usually due to temperature changes. Wind speed measures how quickly air flows from high-pressure to low-pressure areas. Factors influencing wind speed include horizontal pressure gradient, geographical location, elevation, time, and pressure gradient (Keintjem et al., 2023).

2. Materials and Method

This type of research is descriptive research using secondary data in the form of wind direction and speed data obtained from the Jambi Climatology Station during the period 2019–2023. In this study, there are two variables, namely independent variables and dependent variables. Independent variables are variables that do not depend on other variables, while dependent variables are variables that depend on other variables. In this study, the independent variable is wind direction and speed, and the dependent variable is flight activity at Sultan Thaha Jambi Airport.

Wind direction and speed data were obtained from an anemometer installed at the Jambi Climatology Station. To process and analyze wind direction and speed data, Microsoft Excel and the WRPLOT View application (wind rose plot for meteorological data), which is open-source software, were used. The data used consists of daily wind direction and speed data obtained from the Jambi Climate Station of the Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG) over a five-year period, from January to December 2019–2023. The data was initially in hard copy format and was then entered into Microsoft Excel 2019. After that, the data was organized and grouped based on the format, which included year, month, day, hour, wind direction, and wind speed. Systematically, the flowchart for surface wind analysis at Sultan Thaha Airport in Jambi for the period 2019-2023 using the wind rose method can be seen in the following figure.

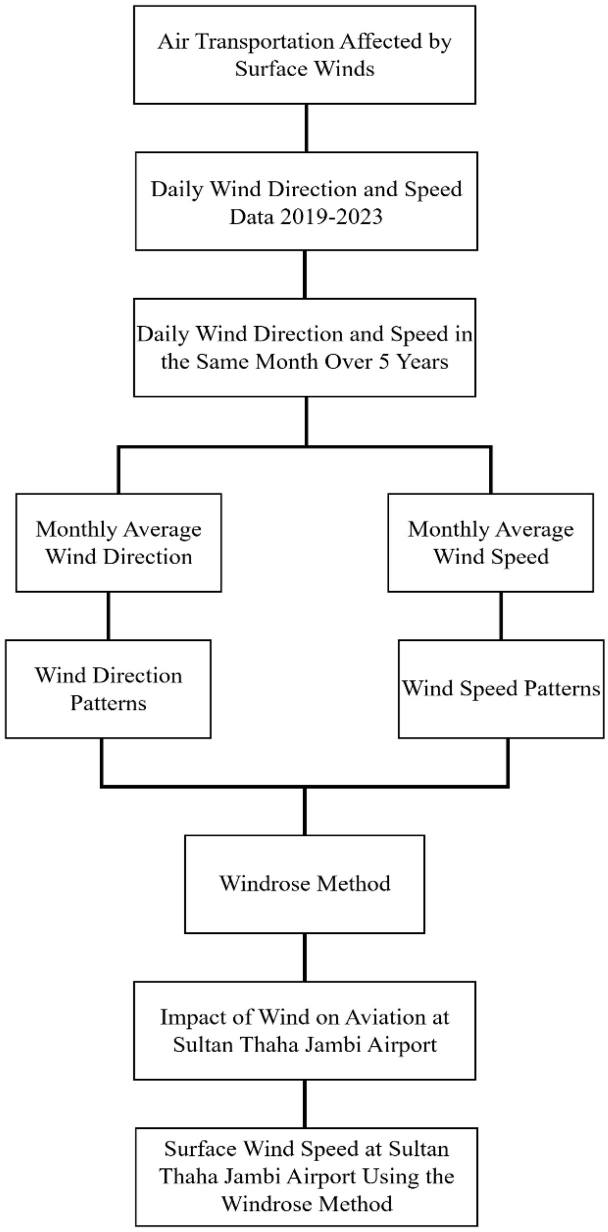


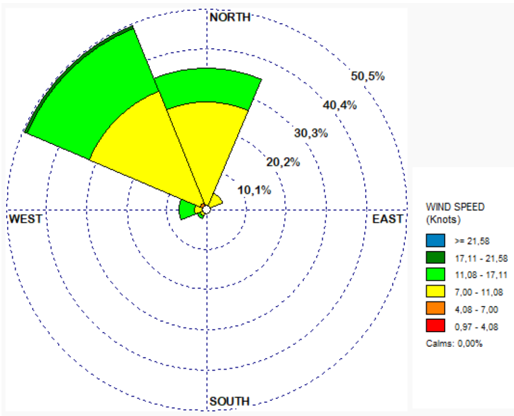
Figure 2. Flowchart for surface wind analysis

Figure 12 shows that the framework begins with identifying the problem to be analyzed. The research objectives can then be determined from this problem. Sultan Thaha Airport in Jambi is a facility for air transportation that is greatly influenced by weather factors, especially surface winds. Data on daily wind direction and speed from 2019-2023 was obtained from the Jambi Climate Station of the Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG). The data was then grouped by month over a five-year period. First, the data were grouped according to the average monthly wind direction to identify wind direction patterns. Second, the data was grouped according to average speed to identify wind speed patterns. These two patterns reveal the influence of wind on the seasons and provide information about surface wind speed at Sultan Thaha Airport in Jambi.

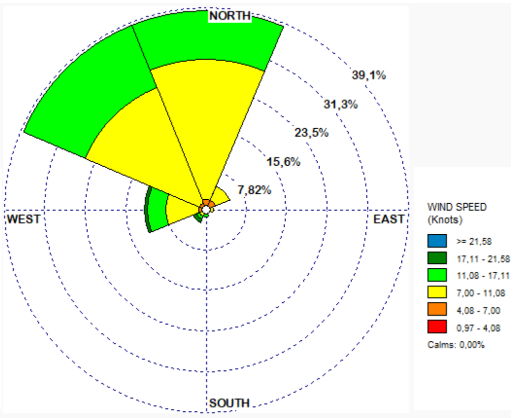
Wind direction and speed diagrams are created using the WRPLOT (Wind Rose Plots for Meteorological Data) application. This application illustrates variations in wind direction and speed and includes wind rose graphs of actual wind speeds. Wind direction and speed data are processed by classifying wind direction into eight cardinal directions: 337–22° (north), 22–67° (northeast), 67–112° (east), 112–157° (southeast), 157–202° (south), 202–247° (southwest), 247–292° (west), and 292–337° (northwest). Wind speed is classified into seven categories: calm (0 knots), 1–4 knots, 4–7 knots, 7–11 knots, 11–17 knots, 17–21 knots, and over 22 knots [3].

3. Results and Discussion

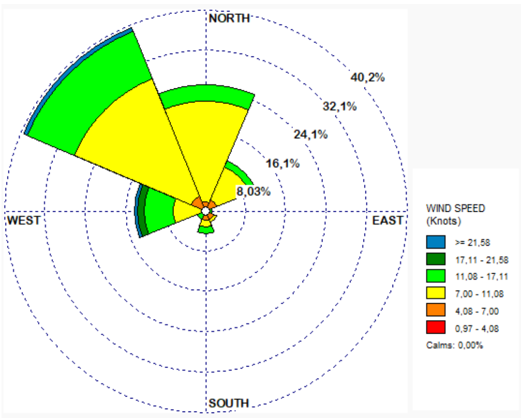
The analysis of surface winds from January, 2019 to December, 2023 using WRPLOT (Wind Rose Plot for Meteorological Data) to produce images of the dominant wind every month. The results of the analysis in January-December can see in Figure 3.



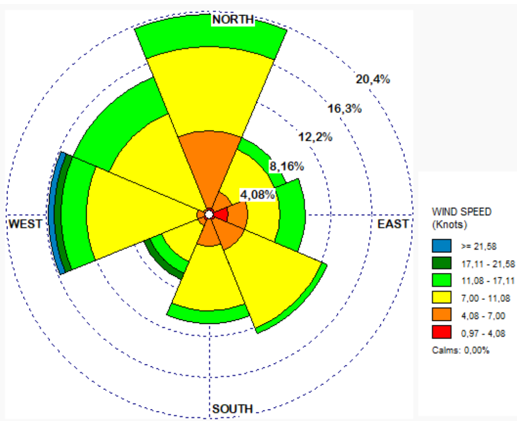
(a)



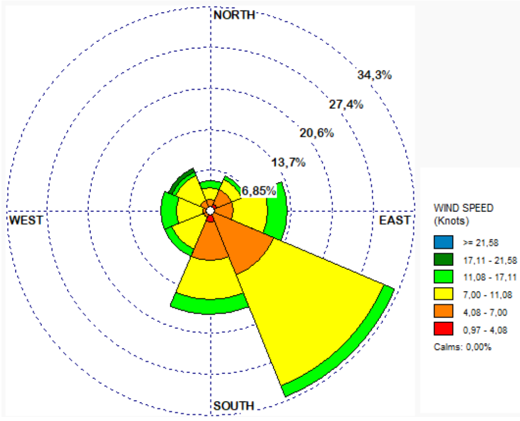
(b)



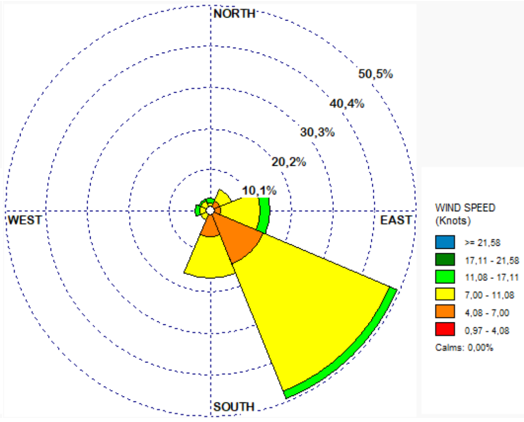
(c)



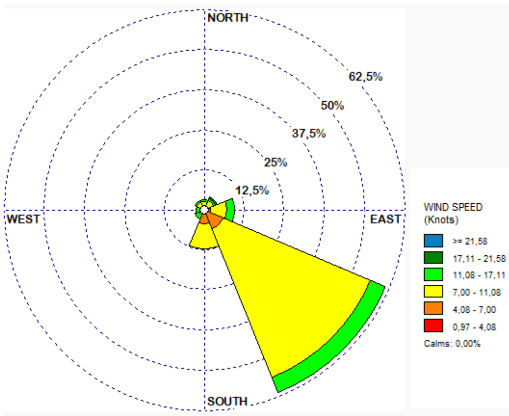
(d)


NORTH
WEST
EAST
SOUTH
34,3%
27,4%
20,6%
13,7%
6,85%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

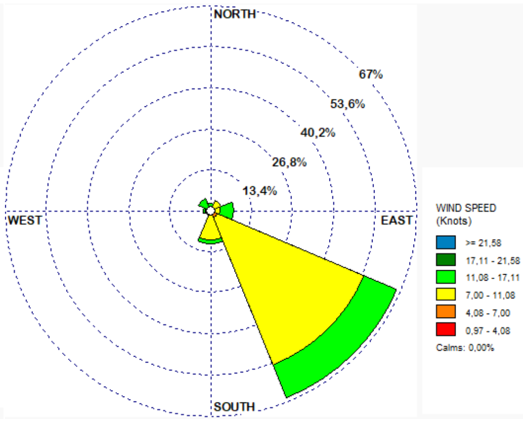
(e)


NORTH
WEST
EAST
SOUTH
50,5%
40,4%
30,3%
20,2%
10,1%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

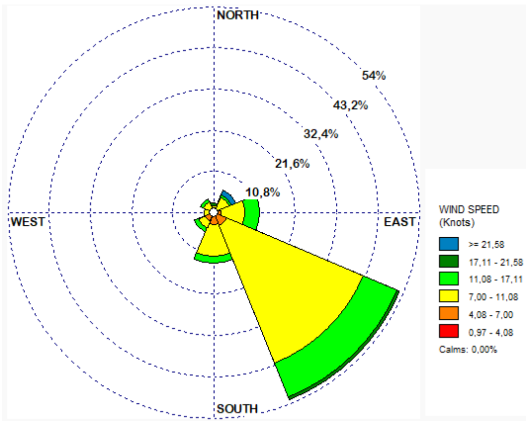
(f)


NORTH
WEST
EAST
SOUTH
62,5%
50%
37,5%
25%
12,5%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

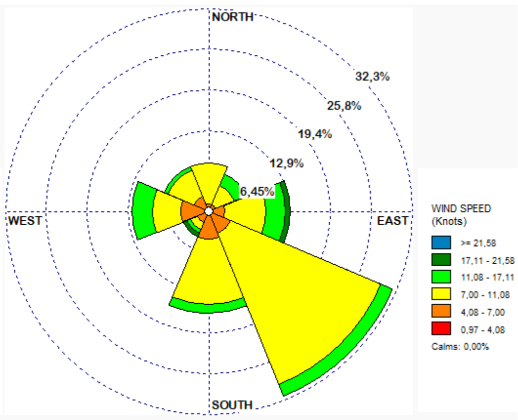
(g)


NORTH
WEST
EAST
SOUTH
67%
53,6%
40,2%
26,8%
13,4%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

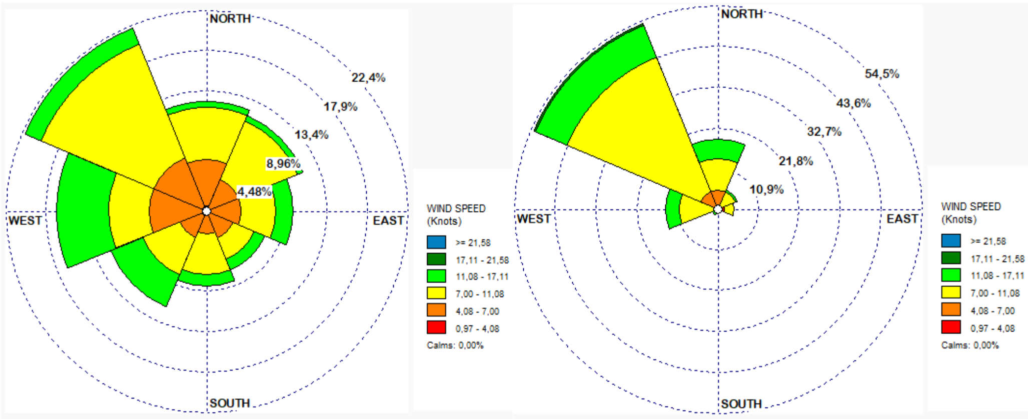
(h)


NORTH
WEST
EAST
SOUTH
54%
43,2%
32,4%
21,6%
10,8%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

(i)


NORTH
WEST
EAST
SOUTH
32,3%
25,8%
19,4%
12,9%
6,45%
WIND SPEED
(Knots)
>= 21,58
17,11 - 21,58
11,08 - 17,11
7,00 - 11,08
4,08 - 7,00
0,97 - 4,08
Calms: 0,00%

(j)



(k) (l)

Figure 3. Surface Wind Patterns (a) January(b) February (c) March (d) April (e) May (f) June (g) July (h)August (i) September (j) October (k) November (l) December

Based on figure 3, the results of data processing that has been carried out, as shown in Figure 3 on the average wind direction that occurs at Sultan Thaha Jambi Airport, it is found that the origin of the wind direction varies from the period 2019 - 2023. The processed wind data is obtained from the Sultan Thaha Station. Wind direction is measured using a cup anemometer on the wind vane sensor.

In January, the average wind direction at Sultan Thaha Airport in Jambi was from the northwest, accounting for 24.37% of the total. In February, the wind came from the northwest and north, accounting for 25.98% of the total. In March , the wind came primarily from the northwest, at 19.35%. In April, the wind came from the north at 13.62%. In May, the wind came from the southeast at 18.28%. In June, the wind came from the southeast at 29.39%. In July, the wind came from the southeast at 40.5%. In August, the wind came from the southeast at 45.16%. In September, the wind originated from the southeast at 30.82%. In October, the percentage was 18.70%. In November, the wind came from the northwest with a percentage of 16.13%. In December, the wind came from the northwest 30.11% of the time.

Wind speed measurement at Sultan Thaha Airport, Jambi is carried out using a cup anemometer mounted on a wind speed sensor. Based on observational data, the mean wind speed ranges from 7.00 to 17.11 knots. When examined on a monthly basis, the frequency of occurrence of wind speeds within this range shows variation throughout the year. The highest frequency was recorded in August at 25.81%, followed by July at 21.94%, and January at 20.65%. In the remaining months, the frequency of occurrence was 14.89% in February, 13.55% in March, 7.33% in April, 14.19% in May, 15.33% in June, 20.67% in September, 10.32% in October, 8.00% in November, and 17.33% in December.

Based on the overall distribution of observational data, the most dominant wind speed range is 7.00–11.08 knots, accounting for 61.5% of total occurrences. Wind speeds in the range of 11.08–17.11 knots were recorded at 18.5%, while the range of 4.08–7.00 knots accounted for 17.2%. Wind speeds in the range of 0.97–4.08 knots occurred at a frequency of 1.6%, and the range of 17.11–21.58 knots at 0.8%. Wind speeds exceeding 21.58 knots were recorded at only 0.3% of total observations, while calm wind conditions were observed at 0.0%.The maximum wind speed on record occurred on September 6, 2019, with a value of 15 m/s, equivalent to 29.16 knots.

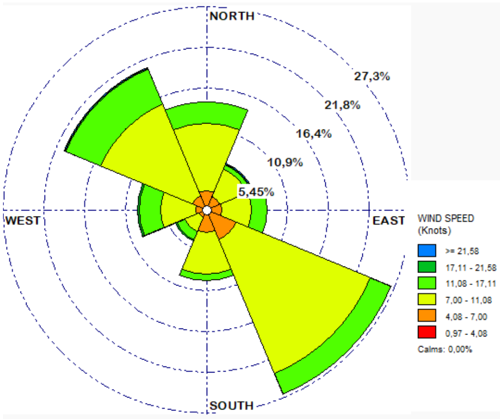


Figure 4. Whole Wind Rose (2019-2023)

Figure 4 shows that the average winds from 2019 to 2023 were predominantly from the southeast (113°-158°) with a percentage of 27.3%, from the northwest (293°-338°) with a percentage of 21.8%, from the north (338°-23°) with a percentage of 16.4%, from the south (158°-203°) with a percentage of 10.9%, from the west (248°-293°) with a percentage of 5.45%, from the east (68°-113°) with a percentage of 2.7%, from the northeast (23°-68°) with a percentage of 1.8%, and from the southwest (203°-248°) with a percentage of 0.9%.

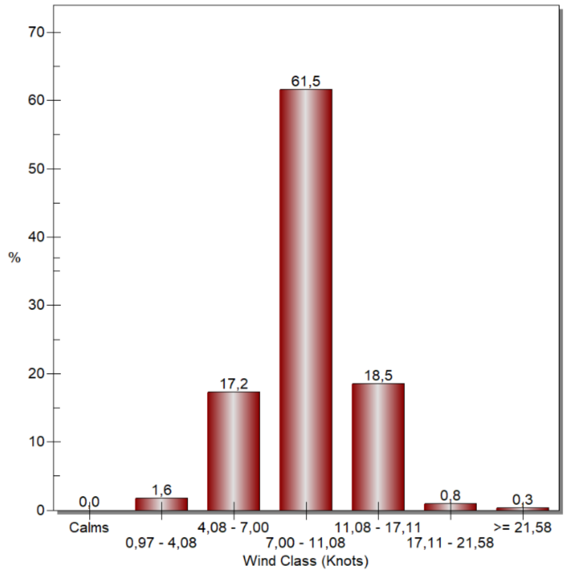


Figure 5. Frequency Distribution of Wind Classes from January to December 2029-2023

Figure 5 shows that the wind speeds of 7.00-11.08 knots accounted for 61.5% of the time, wind speeds of 11.08-17.11 knots accounted for 18.5% of the time, wind speeds of 4.08-7.00 knots accounted for 17.2% of the time, wind speeds of 0.97-4.08 knots accounted for 1.6% of the time, wind speeds of 17.11-21.58 knots accounted for 0.8% of the time, wind speeds of 21.58 knots accounted for 0.3% of the time, and gentle winds accounted for 0.0%. The maximum wind speed occurred on September 6, 2019, at 15 m/s (29.16 knots). Figure 4 shows that the Sultan Thaha Jambi Airport is located in the lowlands of Jambi City. This area is greatly influenced by local and monsoon winds. Wind data analysis shows that the dominant wind direction in this area generally blows from southeast to southwest (easterly to westerly), reflecting seasonal circulation patterns, such as monsoon winds.

Jambi is located in the central part of Sumatra Island. Geographically, it is situated in the equatorial region and has a tropical wet or equatorial climate. The average temperature in Jambi ranges from 24°C to 32°C, with relatively high humidity. This temperature may fluctuate slightly, especially during the rainy season, when it is typically cooler due to fairly intense rainfall. The rainy season usually occurs in Jambi between October and March, while the dry season typically takes place from April to September.

Sultan Thaha Airport in Jambi, with coordinates 01° 38' 08" S 103° 38' 35" E, is the main international airport in Jambi province, serving flights to the city of Jambi. Air transportation has a very high level of safety; even a small error can impact the safety of both crew and passengers. Sultan Thaha Airport is located in the lowlands of Jambi City and is part of an area heavily influenced by wind conditions, both local and monsoon. Based on wind data analysis, the dominant wind direction in this area generally originates from the southeast to southwest (eastern to westerly winds), reflecting seasonal circulation patterns similar to the monsoon.

Jambi, located in the central part of Sumatra Island, geographically straddles the equator and has a humid tropical or equatorial climate. The average temperature in Jambi ranges from 24°C to 32°C, with relatively high humidity. This temperature can fluctuate slightly, especially during the rainy season, which is usually cooler due to the relatively intense rainfall. The rainy season in Jambi typically lasts from October to March, while the dry season occurs around April to September.

From January to March, the dominant wind direction comes from the northwest (300°–350°), which is a characteristic of the west monsoon. This wind generally carries moisture from the Indian Ocean and causes increased rainfall, especially in areas in western Indonesia, including Jambi. Furthermore, from May to October, the dominant wind direction is from the southeast (130°–140°), which is indicative of the east monsoon. As a result, the Jambi region tends to experience a dry season during this period. The wind direction changes again from November to December, with the dominant wind direction shifting back to the northwest, signifying the annual monsoon cycle.

Therefore, the results of this analysis show that the Sultan Thaha Airport area in Jambi has experienced a consistent seasonal shift in dominant wind direction over the past five years. This shows that the area is under the influence of the monsoon wind circulation system, which is part of the regional atmospheric dynamics in Indonesia.

4. Conclusion

The results of the study indicate that the condition of wind patterns that occurred at Sultan Thaha Jambi Airport during 2019–2023 showed that the dominant wind direction changed seasonally. In January to March, the dominant wind direction comes from the Northwest (300°–350°), while in May to October the dominant wind direction comes from the Southeast (130°–140°). This pattern indicates that the Jambi region is influenced by the west monsoon and east monsoon wind systems which alternate every year. And the average wind speed that occurred at Sultan Thaha Jambi Airport during the 2019–2023 period was in the range of 4.42 to 4.78 m/s or equivalent to 8.6 to 9.3 knots, with a maximum speed recorded of 15.0 m/s (29.16 knots) which occurred on September 6, 2019. The minimum speed recorded was 2.0 m/s (3.89 knots). By knowing the condition of surface wind direction and speed, this information can be used to support flight safety, especially in determining runway direction and aircraft maneuvers during takeoff and landing.

References

[1] S. Oktavia, Syafriani, L. Dwiridal, Dan N. Y. Sudiar, "Analysis Of Surface Wind Speed At Minangkabau International Airport For The Period 2011-2020 Using The Windrose Method," *J. Phys.: Conf. Ser.*, Vol. 2582, No. 1, Hlm. 012006, Sep 2023, Doi: 10.1088/1742-6596/2582/1/012006.

[2] A. Fadholi, "Analisa Pola Angin Permukaan Di Bandar Udara Depati Amir Pangkalpinang Periode Januari 2000 – Desember 2011," Vol. 12, No. 1, 2012.

[3] R. W. Saragih Dan P. S. Siregar, "Analisis Data Angin Permukaan Di Bandara Syarif Kasim Ii Pekanbaru Menggunakan Metode Windrose," 2021.

[4] S. Martha Dan B. Rochmat, "Pengaruh Faktor Geografis Terhadap Keselamatan Penerbangan Di Indonesia," *Jlri*, Vol. 9, No. 2, Hlm. 13–23, Jun 2021, Doi: 10.55960/Jlri.V9i2.388.

[5] M. E. Murniati Dan Sudiarti, "Analisis Potensi Energi Angin Sebagai Pembangkit Enegi Listrik Tenaga Angin Di Daerah Banyuwangi Kota Menggunakan Database Online-Bmkg," *Jse*, Vol. 6, No. 1, Apr 2022, Doi: 10.32502/Jse.V6i1.3364.

[6] D. A. Tulandi, J. V. Tumangkeng, Dan F. E. A. Tumbelaka, "Analisis Data Angin Permukaan Di Bandara Sam Ratulangi Manado Menggunakan Metode Wind Rose," Vol. 1, 2020.

[7] C. Cahyana, "Model Hidrodinamika Laut," 2005.

[8] Y. D. Herlambang *Dkk.*, "Model Alat Ukur Kecepatan Angin, Arah Angin, Dan Intensitas Radiasi Matahari," *Jurnal Teknik Energi*, Vol. 16, No. 2, Hlm. 80, Des 2020, Doi: 10.32497/Eksergi.V16i2.2210.

[9] I. Abdullah Dan J. Nurdin, "Kajian Potensi Energi Angin Di Daerah Kawasan Pesisir Pantai Serdang Bedagai Untuk Menghasilkan Energi Listrik," Vol. 2, No. 1, 2016.

[10] T. Wardoyo, "Klasifikasi Angin Berdasarkan Kecepatan Angin Dengan Skala Beafort Pada Perairan Cilacap," 2020.