The Influence Of Weather On Aviation Traffic Performance Aerodrome Control Tower During The Rainy Season At JATSC

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Abstract
Weather conditions are one of the external factors that significantly affect air traffic performance, particularly during the rainy season in tropical regions such as Indonesia. This study aims to analyze the effect of weather parameters on air traffic performance during the rainy season at Jakarta Air Traffic Services Center (JATSC) and to identify which weather parameters have the most significant impact on flight operations. This research employed a quantitative approach with a correlational research design. Data were collected through structured questionnaires distributed to 93 respondents consisting of Air Traffic Controllers (ATC), aviation meteorologists, and airport operations managers, supported by secondary operational and meteorological data during the 2023– 2024 rainy season period. The weather parameters analyzed included precipitation, visibility, wind speed and direction, cloud ceiling, lightning activity, air temperature, and relative humidity. The results indicate that visibility, precipitation intensity, lightning activity, and wind speed are the most influential weather parameters affecting air traffic performance, particularly in relation to flight delays, go-arounds, and flight cancellations. The study concludes that all weather parameters have a significant impact with varying levels of influence, highlighting the need for integrated operational management and weather mitigation strategies to enhance safety and efficiency in air traffic operations at JATSC.

Keywords: Aviation weather; Air traffic performance; Rainy season; JATSC; Meteorological Factors

INTRODUCTION

Soekarno-Hatta International Airport is the main air gateway of Indonesia and one of the busiest airports in Southeast Asia, serving thousands of aircraft movements daily. In 2023, the airport handled approximately 63.15 million passengers, indicating a very high level of air traffic density and operational complexity (Angkasa Pura II, 2024). Such intensive operations make the airport highly vulnerable to external disturbances, particularly adverse weather conditions during the rainy season, which generally occurs from October to April.

Adverse weather is widely recognized as one of the primary causes of operational disruptions in global aviation. According to the International Air Transport Association, approximately 32% of global flight delays are attributed to weather-related factors, resulting in annual economic losses of up to USD 65 billion (IATA, 2024). In Indonesia, these challenges are exacerbated by tropical climate characteristics, where weather conditions can change rapidly, with rainfall intensities reaching 20 -100 mm per hour and convective cloud formations extending up to 15,000 meters in altitude (BMKG, 2024).

The impact of weather on flight operations at Soekarno-Hatta Airport is both significant and measurable. Operational data from Perum Lembaga Penyelenggara Pelayanan Navigasi Penerbangan Indonesia indicate that during the rainy season between 2019 and 2023, departure delays increased by 68% compared to the dry season, with average delays reaching 52 minutes per flight. Additionally, go-around events increased by up to 145%, while flight cancellations rose to 14% of scheduled operations (Perum LPPNPI, 2024). These disruptions not only affect passenger convenience but also generate substantial economic losses, as air traffic management efficiency can decrease by 25-40% under adverse weather conditions (Eurocontrol, 2024).

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Weather conditions influence air traffic performance through reduced visibility, degraded runway conditions, increased Air Traffic Controller (ATC) workload, and potential disruptions to surveillance and communication systems. Given these challenges, a comprehensive and empirical analysis of the influence of weather parameters on air traffic performance during the rainy season is essential. This study is therefore conducted to examine the impact of weather on air traffic performance at Jakarta Air Traffic Services Center (JATSC) and to provide evidence-based recommendations for improving operational efficiency and aviation safety.

Based on the background described above, the research problems formulated in this study are as follows:

1. Which types of weather conditions have a significant influence on air traffic performance at JATSC during the rainy season?
2. To what extent does each weather parameter affect air traffic performance indicators such as flight delays, go-arounds, and flight cancellations at JATSC?

The objectives of this study are:

1. To identify weather parameters that have a significant influence on air traffic performance at JATSC during the 2023-2024 rainy season.
2. To measure the magnitude of the impact of each weather parameter on air traffic performance indicators, including departure delays, go-around events, and flight cancellations.

RESEARCH METHODS

This study employed a quantitative research approach with a correlational research design to examine the relationship between weather conditions and air traffic performance during the rainy season at Jakarta Air Traffic Services Center (JATSC). The quantitative approach was selected to enable objective measurement and statistical analysis of the influence of meteorological parameters on operational performance indicators.

Research Subject and Location

The research was conducted at Jakarta Air Traffic Services Center (JATSC), Soekarno-Hatta International Airport, Tangerang, Indonesia. The subjects of this study were aviation operational practitioners consisting of Air Traffic Controllers (ATC), aviation meteorologists, and airport operations managers who are directly involved in managing flight operations under varying weather conditions (Perum LPPNPI, 2024).

Population and Sampling Technique

The research population included all scheduled commercial flight operations managed by JATSC during the rainy season period from October 2023 to April 2024. The sampling technique used was purposive sampling, with selection criteria based on professional experience and operational expertise. A total of 93 respondents participated in the study, ensuring data validity and reliability through experienced judgment.

Research Variables

The independent variables consisted of eight meteorological parameters, namely precipitation intensity, visibility (Runway Visual Range), wind speed, wind direction, cloud ceiling, lightning activity, air temperature, and relative humidity (BMKG, 2024). The dependent variable was air traffic performance, measured using four indicators: flight departure delays, go-around frequency, flight cancellations, and route or flight level changes (Eurocontrol, 2024).

Data Collection Techniques

Primary data were collected using structured questionnaires with a Likert scale and supported by open-ended questions to capture operational insights from respondents. Secondary data were obtained from Automated Weather Observing System (AWOS), meteorological

reports (METAR, TAF, SIGMET), flight operational databases of AirNav Indonesia, and airport operational records from Angkasa Pura II (Angkasa Pura II, 2024; BMKG, 2024).

Data Analysis and Statistical Model

Data analysis involved descriptive statistics to rank the influence of each weather parameter and calculate mean scores. Correlation analysis was applied to examine the strength of relationships between weather parameters and performance indicators. Content analysis was used for qualitative responses to support quantitative findings. This combination of methods allowed comprehensive interpretation of weather-related operational impacts without excessive statistical complexity (IATA, 2024).

RESULT AND DISCUSSION

This section presents and discusses the findings of the study on the influence of weather conditions on air traffic performance during the rainy season at Jakarta Air Traffic Services Center (JATSC). The results are derived from data collected from 93 experienced aviation practitioners, including Air Traffic Controllers (ATC), aviation meteorologists, and airport operations managers. The analysis integrates quantitative findings from Likert-scale responses and qualitative insights obtained from open-ended questions, allowing a comprehensive interpretation of weather-related operational impacts.

Respondent Characteristics and Operational Context

The respondents represent a highly experienced professional group, with an average operational experience exceeding 18 years and representation from Tower, Approach (APP), and Area Control Centre (ACC) units. This distribution ensures that the findings reflect the full spectrum of operational perspectives across departure, approach, and en-route phases.

Table 1 presents the demographic and operational characteristics of the respondents, including unit assignment and years of experience.

Variable	Category	Percentage (%)
Unit Kerja	Tower	21.5
	APP	31.2
	ACC	46.3
Pengalaman Kerja	> 10 tahun	87.1
Pendidikan	D4/S1 ke atas	72.0

The dominance of senior personnel strengthens the reliability of the findings, as previous studies emphasize that extensive operational experience enhances pattern recognition and decision-making capabilities under adverse weather conditions, particularly for ATC personnel operating in high-density airspace (Bongo & Seva, 2022).

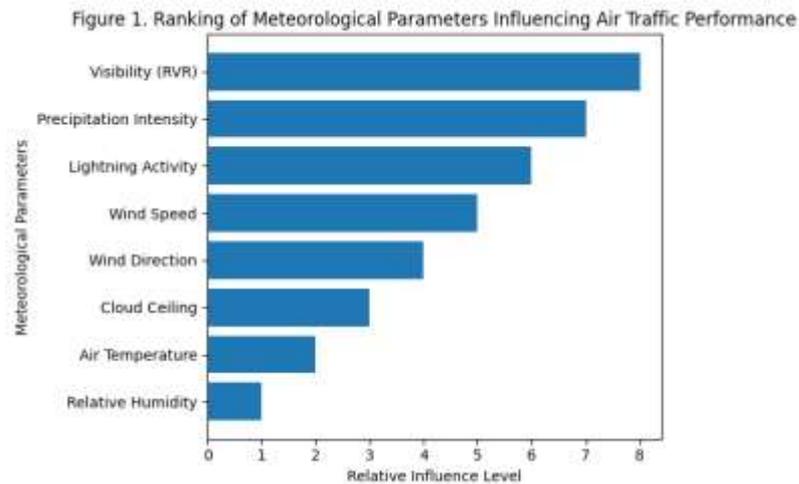## Overall Influence of Weather Parameters on Air Traffic Performance

Figure 1 Ranking of Meteorological Parameters Influencing Air Traffic Perfomance

Figure 1 illustrates the overall ranking of eight meteorological parameters based on their perceived influence on air traffic performance. Visibility (Runway Visual Range) emerged as the most critical parameter, followed by precipitation intensity, lightning activity, and wind speed. These parameters were consistently associated with operational disruptions such as departure delays, go-around occurrences, flight cancellations, and route or flight level changes.

Table 2. Mean Influence of Meteorological Parameters on Air Traffic Performance

Meteorological Parameter	Mean Score	Rank
Visibility (RVR)	4.53	1
Precipitation Intensity	4.41	2
Lightning Activity	4.35	3
Wind Speed	4.28	4
Wind Direction	3.94	5
Cloud Ceiling	3.76	6
Air Temperature	3.12	7

The dominance of visibility as the most influential parameter aligns with international aviation safety literature, which highlights reduced visual reference as a major constraint on runway capacity and approach stability, particularly under Instrument Flight Rules (Gültepe et al., 2019). In tropical environments such as Jakarta, visibility degradation is frequently associated with heavy rainfall and fog formation, exacerbating operational complexity.

Impact on Specific Performance Indicators

The findings indicate that departure delays are the most sensitive performance indicator affected by adverse weather, followed by go-arounds and flight cancellations. Reduced visibility and intense precipitation significantly limit runway throughput, requiring increased aircraft spacing and procedural adjustments that reduce airport capacity. Similar operational impacts have been reported by Eurocontrol (2024), which notes efficiency reductions of up to 40% during adverse weather conditions.

Lightning activity and strong winds were found to contribute notably to go-around events, particularly during the approach phase. This finding is consistent with safety analyses indicating that unstable approaches under convective weather conditions substantially increase the likelihood of missed approaches. Wind direction, while ranked slightly lower overall, plays a critical role in runway configuration decisions due to crosswind and tailwind limitations.

Air temperature and relative humidity showed a comparatively lower but still meaningful influence. Temperature affects aircraft performance through density altitude variations, while

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high humidity serves as an early indicator for fog development, indirectly affecting visibility. These results support previous studies on tropical meteorology, which emphasize the cumulative and interdependent effects of multiple weather parameters rather than isolated phenomena (BMKG, 2024; Oo et al., 2022).

Operational Implications and Discussion

The combined results highlight that weather impacts on air traffic performance are multidimensional and phase-dependent. ATC workload increases substantially during adverse weather as controllers must process rapidly changing meteorological information, coordinate with multiple stakeholders, and implement dynamic traffic management strategies. This increased cognitive demand has been widely recognized as a critical factor affecting operational performance and safety margins (Bongo & Seva, 2022).

The findings reinforce the need for a holistic operational approach that integrates real-time weather monitoring, improved forecasting accuracy, and decision-support tools tailored to tropical weather characteristics. Enhanced collaboration between AirNav Indonesia, BMKG, and airport operators is essential to mitigate weather-related disruptions and improve resilience during the rainy season.

CONCLUSION

Based on the results and discussion of this study, it can be concluded that weather conditions during the rainy season have a significant influence on air traffic performance at Jakarta Air Traffic Services Center (JATSC). Among the analyzed weather parameters, visibility, precipitation intensity, lightning activity, and wind speed are identified as the most influential factors affecting flight operations, particularly in relation to departure delays, go-around occurrences, and flight cancellations. These weather-related impacts increase operational complexity and Air Traffic Controller (ATC) workload, requiring adaptive traffic management and timely decision-making to maintain safety and efficiency. Although other parameters such as air temperature, humidity, cloud ceiling, and wind direction exhibit relatively lower influence, they remain important contributors due to their cumulative and interdependent effects on operational performance. Overall, the findings highlight the necessity of integrated weather management, enhanced forecasting accuracy, and close coordination among air navigation service providers, meteorological agencies, and airport operators to mitigate weather-related disruptions and strengthen the resilience of air traffic operations, particularly during the rainy season.

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