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Case Study of Aircraft Operational Noise Level Distribution Patterns at Zainuddin Abdul Madjid International Airport

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Abstract. Aircraft operational activities, especially in the airport area, are a major source of noise that can affect environmental comfort and health, including aircraft operations at Zainuddin Abdul Madjid International Airport. This study aims to determine the noise level due to aircraft operations and map the noise distribution pattern as a basis for environmental management planning. The method used in this research is a descriptive quantitative method. Measurements of noise and environmental conditions (wind speed, wind direction, and air humidity) were carried out at a distance of 0 m, 30 m,175 m, 300 m, 500 m, and 1 000 m. The noise level was measured using the Sound Level Meter (SLM) measuring instrument in decibel units. Analysis and mapping were done using Surfer 28 software. The results showed that the noise level ranged from 44 to 97 dBA. At a distance of less than 100 m, the noise level threshold value, as stipulated in the Minister of Environment Decree Number 48 of 1996. In addition, the resulting noise distribution shows a radial pattern. The radial pattern is characterized by the spread of sound that spreads from one point source in a circular manner, and the intensity tends to decrease as the distance increases.

Keywords: Aircraft, Airport, Distribution Pattern, Noise, Operational, Surfer.

1. Introduction

Air transportation is a popular mode of transportation for many people from various backgrounds. This is because air transportation is the primary mode of transportation, offering seemingly shorter or faster travel times, thus saving users time (Pratama and Yudianto, 2024). Aviation is a crucial part of the air transportation system, capable of rapid movement, high-tech use, intensive and reliable capital management, and optimal safety assurance. However, with increasingly fierce economic competition, safe and supportive transportation facilities are essential, including aviation [1]. Aviation hubs are generally found at airports, defined as areas equipped with facilities to accommodate the movement of aircraft, passengers, and cargo [2]. Zainuddin Abdul Madjid International Airport is one of the main air transportation gateways in the West Nusa Tenggara region. This airport is a domestic and international airport located in Central Lombok Regency, West Nusa Tenggara. Flight frequency at BIZAM shows an increase annually, from 12,916 flights in 2021 to 24,878 flights in 2024. This increase in the number of flights can have both positive and negative impacts on the environment. One negative impact of this increase in flights is noise [3].

Noise according to the Decree of the Minister of Environment of the Republic of Indonesia Number 48 of 1996 concerning Noise Level Threshold Values, "Noise is an unwanted sound from a business or activity at a certain level and time that can cause disturbances to human health and environmental comfort." Noise is a problem that has not been addressed properly until now, because noise is one of the factors that is ignored in the work environment so that it can become a serious threat to health [4]. The impact of noise is significant on environmental quality, affecting human health and ecosystem

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balance. Noise in the apron work area can have a direct impact on workers and service users, while exposure from aircraft operations reaches surrounding residential areas, potentially disrupting biodiversity. Noise at the airport can come from aircraft operations including landings, takeoffs, aircraft maintenance and aircraft engine testing [5]. The noise generated occurs not only in the airport area, but its impact will also be felt by the surrounding community, both inside and outside the airport area.

Based on the existing problems, there is a high potential for them to spread to various areas. This research is crucial for understanding the extent of noise's impact on the surrounding environment. The results can inform the formulation of mitigation policies to minimize its negative impacts on human health and the ecosystem. The objective of this research is to measure, map, and analyze the noise levels generated by aircraft operations in the BIZAM area.

2. Method

2.1 Research Location

The research location was Zainuddin Abdul Madjid International Airport, located in Tanak Awu Village, Pujut District, Central Lombok Regency, West Nusa Tenggara. Data collection was conducted in April 2025 during the day, namely 09:00-14:00 in accordance with Kep-48/MenLH/11/1996. Measurements were taken at points in the apron area, vehicle parking, and airport access roads, the details of which are presented in Figure 1.

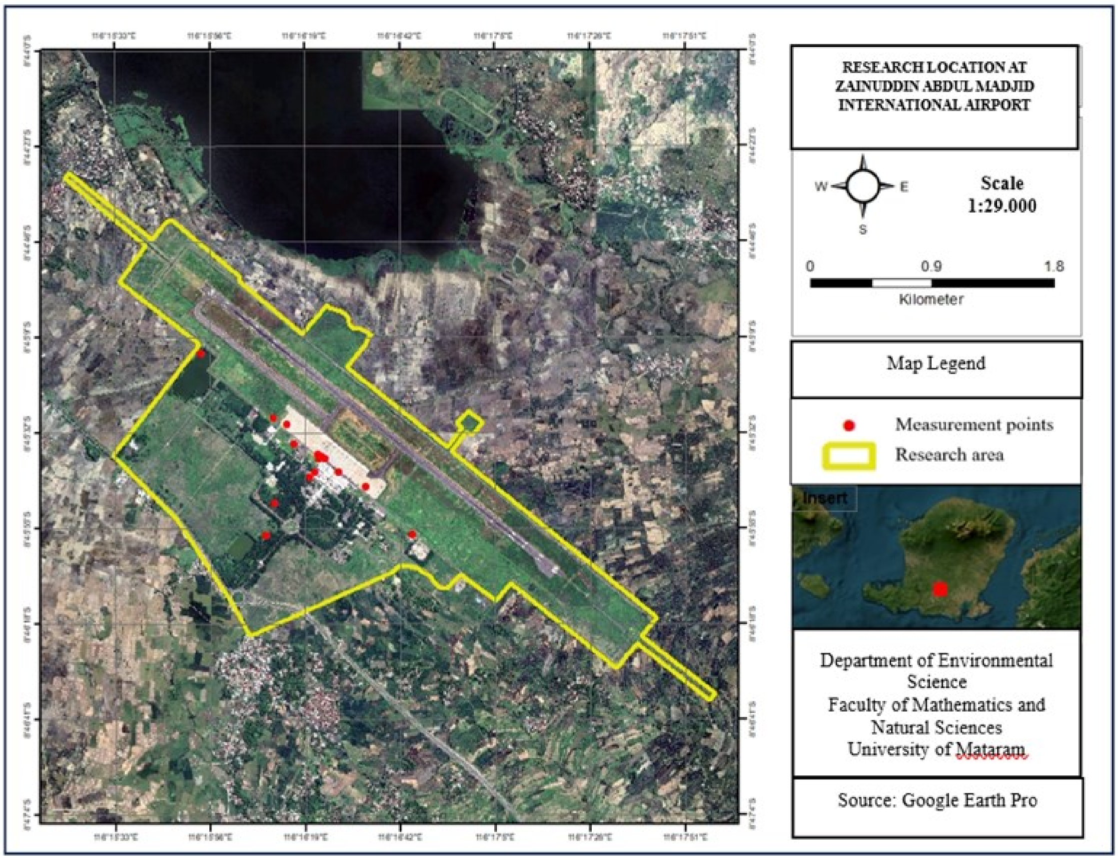

Figure 1. Map of the research location at Zainuddin Abdul Madjid International Airport, West Nusa Tenggara

2.2 Work procedures

The data sources for this study include primary and secondary data. Primary data were obtained directly through noise level measurements at various points and environmental conditions. Secondary data came from various external sources such as literature, flight schedules, number of flights, aircraft types, and other relevant supporting data [6]. The tools used in this study included a Sound Level Meter Smart

Sensor AS824, Surfer 28, Excel, Google Earth, an anemometer, stationery, a camera, ear protection (ear plugs), and a vehicle. Data collection was carried out through observation, noise level measurements, and environmental conditions. Observations at the airport focused on aircraft operations, weather conditions, and the physical characteristics of the measurement location to ensure the accuracy of the noise data. Noise measurements were conducted by selecting points and distance ranges using purposive sampling at points 0 m, 30 m, 175 m, 300 m, 500 m, and 1,000 m from the source to describe the characteristics of noise exposure, which was supported by a literature review related to BIZAM activities and environmental factors.

Noise levels were measured using a Sound Level Meter (SLM) at 30–130 dBA and 35–130 dBC. Sampling was conducted using the grab sampling method, with data readings every 5 seconds for 1 minute. Data were collected from 32 points (16 small aircraft and 16 large aircraft) on the apron, parking lot, and access road. The aircraft measured were grouped into narrow-body (small) and wide-body (large). Large aircraft with turbofan engines exhibit high-frequency noise, while turboprops exhibit low-frequency noise [7]. Environmental conditions (wind direction, wind speed, humidity) were also accurately measured to understand their influence on noise levels and patterns.

2.3 Data analysis

This study analyzes noise level data and its distribution patterns based on operational measurements of aircraft in the BIZAM area. Noise analysis was conducted using the equivalent noise value (Leq), which describes the average sound energy level in decibels (dB) according to the SNI 8427:2017 standard. The equation used can be seen in equation 1.

$$Leq = 10 \log \left[\frac{1}{n} \Sigma_{i=1}^{n} \, 10^{0,1.Li}\right] dBA$$

Information:

Leq : Equivalent continuous noise level (dBA)

n : Amount of Measurement Data

Li : The i-th noise level measured in decibels (dB)

The noise distribution pattern was analyzed through contour maps generated by Surfer 28 software. Surfer interpolates field data (coordinate points and measurement results) to visualize the spatial distribution of noise levels and identify zones based on color gradation.

3. Result and Discussion

3.1 Results

High noise levels can have negative health impacts, such as hearing loss, sleep problems, and stress. Measurements were taken at six points at varying distances from 0 to 1000 m in three time periods (morning, noon, and evening) and in three main directions (southeast, southwest, and northwest). Readings were taken every five seconds for one minute (12 readings), and then the average noise level was calculated using the Equivalent Continuous Sound Level (Leq) parameter. The noise level data are presented in Figure 2. The measurement results show that noise levels vary significantly, ranging from 44 to 97 dBA. The use of a surfer in this study visualizes noise distribution patterns, making it easier to identify areas with high and low intensity. This information is crucial for decision-making regarding airport environmental management, including mitigating the impact of noise on the surrounding community. The figure below shows the distribution patterns of operational noise levels from large and small aircraft at BIZAM.

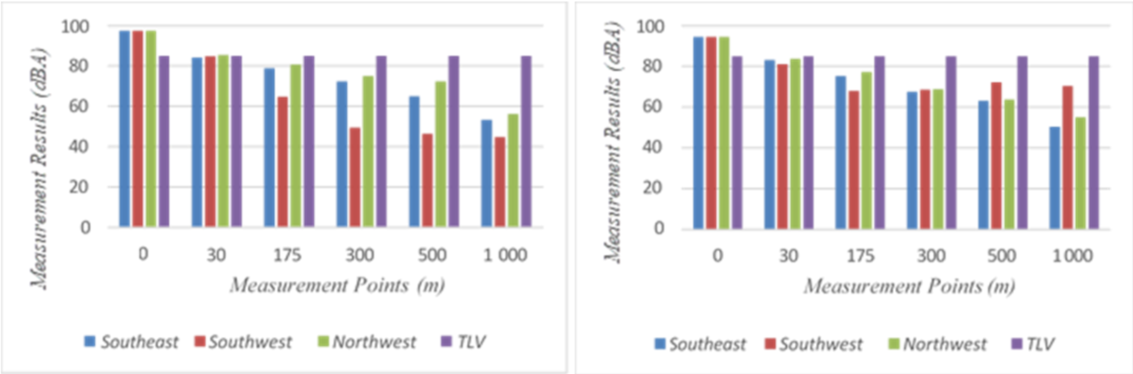

Figure 2. Measurement of noise level of (a) large aircraft and (b) small aircraft

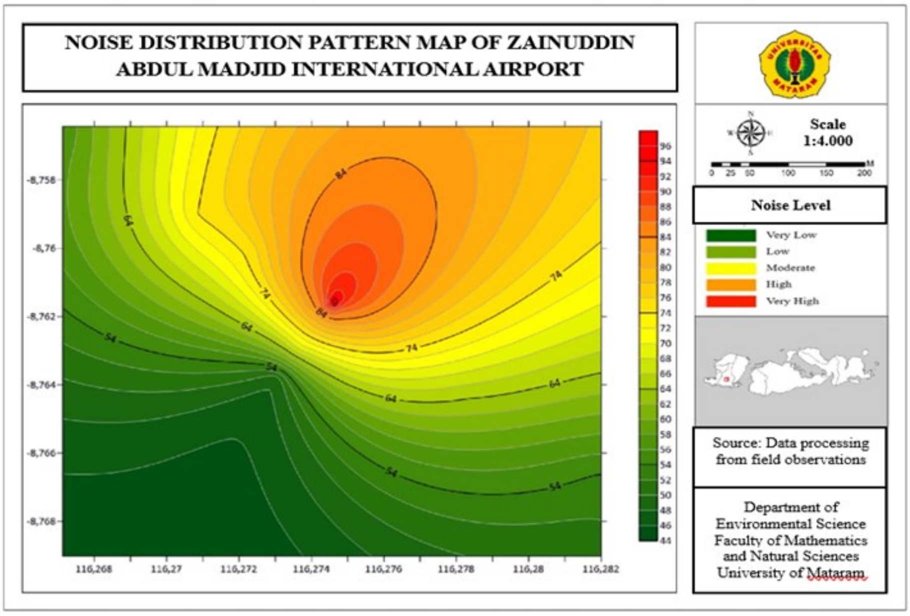

Figure 3. Measurement of Noise Level of Large Aircraft

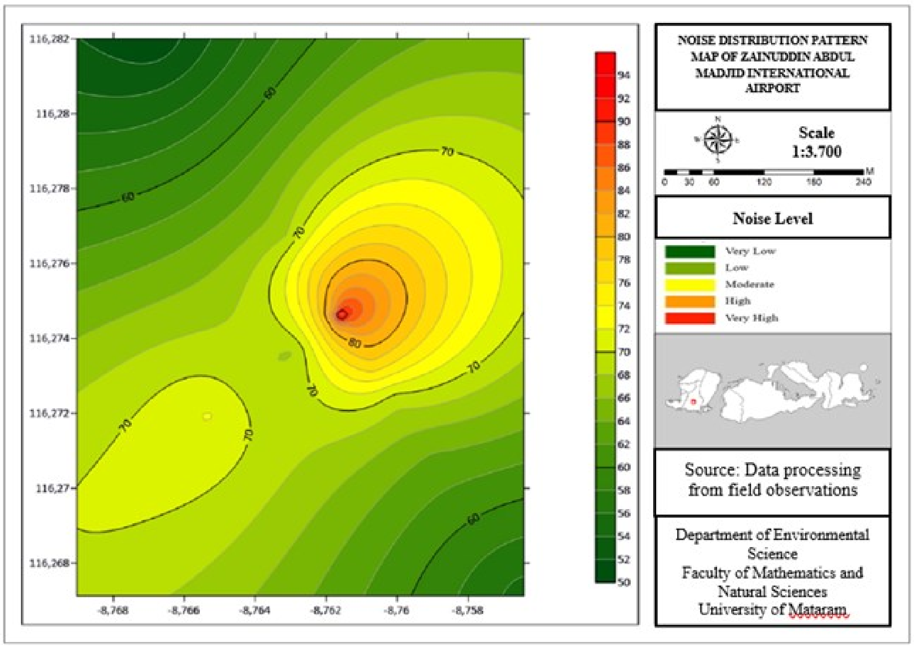

Figure 4. Measurement of Noise Level of Small Aircraft

3.2 Discussion

Airport activities, particularly aircraft operations, are a significant source of noise that can potentially impact the health of workers, service users, and the surrounding community. Noise levels are influenced by aircraft type, measurement distance, environmental conditions (humidity, wind speed, and direction), physical barriers (buildings and vegetation), and transportation activities. The main factor influencing noise level variations is aircraft engine characteristics. Turboprop aircraft, such as the ATR 72, produce noise between 78.7–94.5 dBA, while wide-body aircraft with CMF56 turbofan engines reach 83.9–97.3 dBA on the apron area. This difference is consistent with the findings of Piccirillo et al. [8], which confirmed that turbofan engines produce greater thrust and air volume, significantly contributing to noise levels.

The relationship between distance from the source and noise level is clearly evident, with sound intensity tending to decrease with increasing measurement distance. This decrease in noise level occurs because distance plays a significant role in reducing the intensity of the sound received. Wati (2020) states that the greater the distance from the sound source, the lower the resulting noise level. Determining the location of these measurement points facilitates comparison and evaluation of the influence of factors such as buildings, vegetation, and vehicle activity on noise levels. Narayana et al. [9] stated that environmental conditions such as temperature, humidity, wind speed, and direction significantly affect the intensity of noise received. The noise distribution pattern in BIZAM shows a correlation with meteorological conditions. The noise level measured by a large aircraft shows a higher humidity of 84% with clear weather and a wind speed of 8.5 km/h with a dominant northwest direction. Figure 3 shows that in measurements of a small aircraft, the humidity recorded was 81% with clear weather, and a wind speed of 7.9 km/h with the wind blowing northwest. This wind speed significantly affects sound distribution, pushing sound waves higher and stronger toward the northwest. The measurements conducted show that noise levels for large and small aircraft tend to be higher toward the west. The northwest direction specifically recorded higher levels compared to the opposite direction.

Noise level measurements in the southwest direction show a decreasing pattern at a distance of 175 m, followed by an increase again at 300 m. This decrease is caused by the presence of a physical barrier in the form of a terminal building. Tall buildings such as terminals function as barriers that effectively reduce sound intensity in the area behind them. The height of a barrier also increases its effectiveness in reducing noise [10]). In addition to buildings, vegetation has been proven to be an effective natural barrier in reducing noise levels. Figure 4 shows the significant contribution of vegetation (trees, shrubs, other plants) through the process of absorbing, breaking down, and blocking sound waves. Vegetation is not only beneficial acoustically, but also improves air quality, environmental beauty, and comfort [11].

Research consistently demonstrates the important role of trees as a natural noise mitigation solution at airports. This finding is supported by Yofianti and K Usman [12], who revealed that plant arrangements (trees, shrubs, low plants) were effective in reducing noise by up to 12.25%. This study found a higher effectiveness, namely a reduction of up to 20.93%, most likely due to the physical characteristics of the rain tree, which is dominant around the airport. Rain trees are very effective because of their wide and shady crowns, dense and dense leaves, fast growth, long lifespan, and tall trunks and strong roots, making them ideal as natural noise barriers [13]. This effectiveness is consistent with research by Cornacchia et al. [14], which states that noise intensity is significantly influenced by vegetation characteristics such as distance between plants, density, height, type, and canopy size (width and height). Trees with dense and thick leaves that grow densely around the trunk have good sound attenuation capabilities.

Vehicle activity also affects noise levels, with increased traffic volume correlating with increased noise levels. The highest noise levels are not always directly proportional to vehicle volume; factors such as vehicle type, road conditions, and driver behavior also influence these. Overall, noise level data in BIZAM ranged from 44 dBA to 97.3 dBA. At distances less than 100 m from the source, noise levels consistently exceeded the threshold value of 85 dBA as stipulated in the Decree of the Minister of Environment No. 48 of 1996. This condition indicates continued high noise exposure in several areas around the airport, underscoring the urgency of serious mitigation and environmental management measures.

The noise distribution pattern due to aircraft operational activities at BIZAM during the measurements showed a radial distribution pattern. This pattern indicates the propagation of sound from a single source point that spreads circularly through the air at the speed of sound. The radial pattern generally shows a decrease in noise intensity with increasing distance from the sound source [15]. The noise distribution pattern visualization in Figures 4 and 5 shows the distribution of noise levels through color gradations, with dark green (44–64 dBA) indicating a safe area, and yellow (64–74 dBA) indicating potential long-term discomfort. The orange zone (74–84 dBA) is close to the quality standard and has the potential to cause hearing damage, while the red zone (>84 dBA) significantly exceeds the safe limit, posing a high risk of causing serious hearing loss. This visualization is crucial for identifying high-risk areas, supporting strategic decision-making regarding personal protection, operational management, and noise mitigation in the airport area.

4. Conclusion

The noise levels and distribution patterns of aircraft operating at Lombok Airport exhibit a radial distribution pattern. This radial distribution pattern is strongly influenced by aircraft size, distance from the aircraft, infrastructure, vegetation, and wind speed and direction. Large aircraft produce higher noise levels than small aircraft. The greater the distance from the operating aircraft (the sound source), the lower the noise level. The position and height of infrastructure (buildings) can hinder the distribution of noise generated by aircraft operating in the Lombok Airport area. Wind direction and speed play a major role in determining the range and distribution of noise from aircraft; higher wind speeds will expand the distribution. The results of measurements closest to the sound source, namely 0 m, the noise level has been proven to exceed the noise quality standard of 85 dBA, indicating very high exposure at that location.

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6. Declaration

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