Journal on Transportation System and Engineering
ISSN: 3059 9865(Print) 3059-9873(Online)
Vol. 1. Issue 2, 2025(December): 1-10
DOI: https://doi.org/10.3126/jotse.v1i2.87727
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Research Articles
Received Date: March 29, 2025
Revised Date: September 28, 2025
Accepted Date: November 20, 2025
Published Date: December 21, 2025

Assessment of Air Traffic Noise level: A Case Study of Chiang Mai International Airport

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Abstract

This study aims to analyze the aircraft noise levels at Chiang Mai International Airport and assess the impact of noise pollution on the surrounding areas. The Weighted Equivalent Continuous Perceived Noise Level (WECPNL) index was used as the primary indicator. Noise level measurements were conducted at 6 noise measuring point following the guidelines of the International Civil Aviation Organization (ICAO, 2018) and the Pollution Control Department (2021). The results indicated that the majority of the surrounding areas had noise levels within the standard limits, except for the northern runway end, where the WECPNL value was 70.7, slightly exceeding the standard. This area requires land-use control measures to prevent impacts on the nearby communities. The study also found a correlation between noise levels and factors such as distance from the runway, aircraft takeoff and landing directions, and flight frequency.

Spatial data analysis using the Inverse Distance Weighting (IDW) method clearly presented the noise level distribution and can be effectively applied in planning noise management strategies for airport areas. The findings propose various measures to mitigate aircraft noise impacts, such as designing appropriate flight paths, adjusting land-use zones, developing noise-reducing aircraft technologies, and adhering to ICAO guidelines and noise standards set by relevant authorities in Thailand. These measures aim to align with international standards and minimize noise pollution impacts on surrounding communities.

Keywords: Aircraft Noise, Noise Level Airport, Noise Contour WECPNL Method, Chiang Mai International Airport

1. Introduction

Airports serve as gateways connecting economic centers, tourist destinations, and government hubs. Air transportation has seen significant advancement, particularly at large and popular airports. Chiang Mai International Airport, serving as the aviation hub of Northern Thailand, has gained considerable popularity as a tourist destination. Statistical data from 2019 to 2023 ranks it as the fourth busiest airport in Thailand (State of Thai Aviation Industry [CAAT], 2023). This rapid economic growth has led to increased air traffic density. In 2022, the airport served 10 scheduled airlines with a total of 33,185 flights, representing a 51.57% increase (Airports of Thailand [AOT], 2023). The rise in flight frequency correspondingly increases aircraft noise exposure.

Frequent exposure to aircraft noise in the surrounding communities of Chiang Mai International Airport can lead to significant health impacts. If the noise level exceeds 70 decibels, it may cause anxiety, discomfort, hearing issues, and vascular problems. If noise exceeds 80 decibels, it can severely affect overall health and, if prolonged, may cause temporary or permanent hearing loss (Suma'mur, 2013; Correia et al., 2013). Prolonged exposure to high noise levels may also impair work performance. These conditions lead to distress among residents, reducing their quality of life and potentially causing damage to the community (Thongsun, 2007), which results in complaints to the airport authority.

Given the significance of these issues, the researcher is interested in studying the noise levels from air traffic at Chiang Mai International Airport. The study aims to measure noise levels at the airport in Chiang Mai and calculate the noise index using the Weighted Equivalent Continuous Perceived Noise Level (WECPNL) method, following the guidelines of the International Civil Aviation Organization (ICAO).

Previous studies have highlighted similar concerns at other airports. Research by Nofriandi et al. (2018) at Raja Haji Fisabilillah airport in Tanjung Pinang found significant noise impacts, with levels reaching 95.24 dB(A) near takeoff points.

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Their study revealed that points closest to aircraft takeoff positions recorded the highest noise intensities, with WECPNL values exceeding 75.30 in some areas. These findings emphasize the importance of comprehensive noise monitoring and management, particularly in areas directly under flight paths and near takeoff points. Their methodology, which followed ICAO guidelines for measurement points at various distances from the runway (300-4000 meters), provides a valuable framework for similar studies at other airports. The correlation they found between noise levels and factors such as distance from the runway, aircraft operations, and flight frequency aligns with the objectives of this current study at Chiang Mai International Airport.

Other related studies have also examined various aspects of airport noise impacts. Research by Thongsun (2007) at Suvarnabhumi Airport assessed noise effects on surrounding communities, while Riyangga et al. (2014) analyzed noise pollution's impact on worker health and safety in airport ground handling areas. Additionally, Correia et al. (2013) found significant associations between aircraft noise exposure and cardiovascular-related hospital admissions in their multi-airport study. These studies collectively demonstrate the wide-ranging impacts of airport noise on both community health and operational safety, further supporting the need for comprehensive noise assessment and management strategies.

2. Methodology

2.1 Scope of the study

2.1.1 Scope of the Area

The study utilized aircraft noise level measurement data from 6 noise measuring point in Chiang Mai Province (Airports of Thailand Public Company Limited, 2023). These measuring points were located along the runway and in surrounding communities, as shown in Figure 1.

Figure 1. Noise measuring point at Chiang Mai International Airport (*Airports of Thailand Public Company Limited, 2023)*

2.1.2 Scope of Time

The data collection was conducted from November 15-21, 2023.

2.2 Data collection

2.2.1 Air Traffic Volume Statistics

The primary data collected from field measurements include aircraft noise level measuring at 6 points location in Chiang Mai Province. The data collection focused on noise levels during aircraft take-off and landing. The secondary data consist of aircraft movement frequency, aircraft types, airport layout, and total passenger data for Chiang Mai International Airport in 2023.

2.2.2 Noise measuring point

The measurement points were established according to International Civil Aviation Organization recommendations (ICAO, 2018), with measurements taken at distances of 300 and 600 meters parallel to the runway, as well as 1,000 and 2,000 meters from both runway ends. These locations align with the noise certification reference measurement positions described in Annex 16, Volume 1. The detailed positions of the measurement points

Table 1. Noise measuring point

No.	Points Location	Distance from Runway (m)	Coordinate
1	Northern Runway End (Faculty of Agriculture, Chiang Mai University)	1,000	X = 495902 Y = 2077938
2	Passenger Terminal Front Parking Area (Eastern side of Chiang Mai International Airport)	600	X = 496579 Y = 2075538
3	Southern Runway Area in front of Fire Station (Airside Zone)	300	X = 496516 Y = 2074575
4	Ton Kuk Community, Moo 7, Suthep Sub-district, Mueang District, Chiang Mai Province (Western side of Chiang Mai International Airport)	300	X = 495701 Y = 2074098
5	Mae-Hia Community near Mae-Hia Municipality, Mueang District, Chiang Mai Province (Southeastern side of Chiang Mai International Airport)	2,000	X = 496184 Y = 2071900
6	Ban Umong Community, Suthep Sub-district, Mueang District, Chiang Mai Province (Northwestern side of Chiang Mai International Airport)	600	X = 495535 Y = 2076865

2.3 Data Analysis

2.3.1 Noise measurement method

The noise levels at the airport were measured using both permanent and mobile Sound Level Meters. Data was collected during aircraft movements, specifically during landing and take-off. The equipment used for these measurements is shown in Figure 2.

(A) Fixed-Station Sound Level Meter (B) Mobile Sound Level Meter

Figure 2. Sound Level Meter

Mobile level meters are precision instruments designed for portable noise monitoring applications with measurement capabilities ranging from 30-140 dB(A) and 35-140 dB(C) across a frequency response of 20 Hz to 20 kHz. These devices comply with IEC 61672-1 Class 1 or Class 2 standards, providing measurement accuracy within ±1.4 dB for Class 1 and ±2.0 dB for Class 2 instruments. The meters feature 0.1 dB resolution with selectable time weighting options including Fast (125 ms), Slow (1 s), and Impulse (35 ms) responses. Technical specifications include 32-128 GB internal data storage capacity, 12-24 hours of continuous battery operation, and operational temperature range from -10°C to +50°C. Connectivity options encompass USB 2.0, Bluetooth 4.0, and Wi-Fi 802.11b/g/n interfaces, with total instrument weight typically ranging from 300-800 g including battery.

Fixed-station sound level meters represent permanent installations designed for continuous environmental noise surveillance, featuring extended measurement ranges of 25-140 dB(A) with enhanced dynamic range capabilities. These systems operate reliably across extreme temperature conditions from -40°C to +70°C while maintaining IP65/IP67 weather protection ratings. Power management incorporates solar panel systems ranging from 20-100W capacity coupled with battery backup systems providing 7-14 days of autonomous operation without solar charging. Data management capabilities include GSM/4G/LTE, LoRaWAN, or Ethernet connectivity options for real-time data transmission, with local storage capacity sufficient for 1-5 years of continuous monitoring data. Remote access functionality provides web-based interfaces for real-time monitoring, configurable threshold-based alert systems via SMS/email notifications, and remote calibration verification capabilities with annual on-site calibration requirements. Installation specifications require mounting heights of 3-4 meters above ground level, minimum distances exceeding 1 meter from reflective surfaces, mandatory wind screen protection for outdoor applications, and concrete foundation systems with proper grounding for lightning protection.

2.3.2 Method of calculating the noise index at the airport

The calculation of aircraft noise levels using the Weighted Equivalent Continuous Perceived Noise Level (WECPNL) method is a standard approach for assessing the impact of aircraft noise. This metric follows the guidelines of the International Civil Aviation Organization (ICAO) and accounts for variations in noise perception during different times of the day by applying different weighting factors (Ministry of the Environment Japan, 2023). The general formula used is:

$$dB(A) = 10log\ [\frac{10^{\frac{L1}{10}} + 10^{\frac{L2}{10}} + 10^{\frac{L3}{10}} + \ldots + 10^{\frac{Ln}{10}}}{n}] \qquad (1)$$

Where,

$dB(A)$: Average Noise level

L: The Noise Value at the Time of plane activities

N: Number of Aircraft

The calculation of aircraft noise levels using the Weighted Equivalent Continuous Perceived Noise Level (WECPNL) method is a standard approach for assessing the impact of aircraft noise under formula (1) using the following equation (ICAO, 2018; Ministry of the Environment Japan, 2023) and accounts for variations in noise perception during different times of the day by applying different weighting factors. The general formula used is:

$$WECPNL = dB(A) + 10logN - 27 \qquad (2)$$

where,

$dB(A)$: Average Noise level

N: Number of arrivals and departures in 24 hours

2.3.3 Spatial Estimation Using the Inverse Distance Weighting (IDW) Method

Watson & Philip (1985) described spatial estimation using the Inverse Distance Weighting (IDW) method as an interpolation technique that estimates values at unknown locations based on sampled points. The influence of each sample point decreases as the distance from the estimated cell increases. Consequently, points closer to the target cell are assigned higher weights than those farther away. The number of points used for interpolation can be specified, or all points within a predefined radius can be included in the estimation process, as shown in Figure 3.

The IDW method is particularly suitable for variables that are distance-dependent, where each sample point influences the estimation based on its proximity. This approach is effective for mapping variables that vary smoothly over space, such as noise levels.

A key parameter in IDW interpolation is the power value of the equation. A higher power value places more emphasis on nearby points, leading to a less smooth surface. Conversely, a lower power value distributes influence more evenly across the points, resulting in a smoother interpolated surface, as shown in Figure 4.

For this study, IDW was applied to analyze noise level distribution patterns, using spatial interpolation based on noise measurements. A buffer of 3 kilometers around Chiang Mai International Airport was defined as the boundary for environmental settings to ensure a focused analysis of aircraft noise impacts.

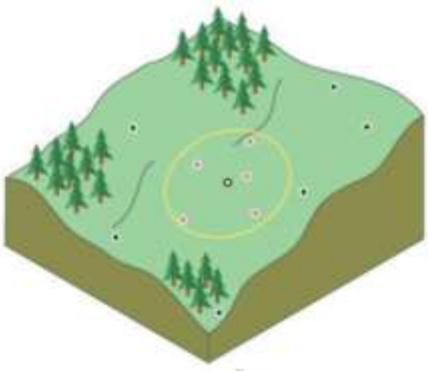

Figure 3. Concept of Spatial Estimation Using the IDW Process (ESRI, 2023)

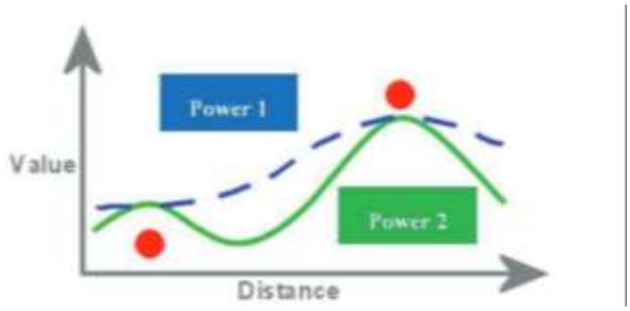

Figure 4. Comparison of Surfaces Estimated with Different Power Values (ESRI, 2023)

3. Results and Discussion

3.1 Results of Noise Measurements

3.1.1 Noise Level Measurements

The noise level measurements were conducted at 6 points location around Chiang Mai International Airport, located in both the runway area and surrounding communities. The results for each points location are as follows:

Points Location 1, located at the northern end of the runway near the Faculty of Agriculture at Chiang Mai University, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 65.9-66.5 dBA, a maximum noise level (L_{max}) between 92.4-95.0 dBA, and a day-night average noise level (L_{dn}) between 69.8-70.8 dBA.

Points Location 2, located at the parking lot in front of the passenger terminal on the east side of the airport, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 61.9-65.2 dBA, a maximum noise level (L_{max}) between 79.5-92.6 dBA, and a day-night average noise level (L_{dn}) between 66.0-69.2 dBA.

Points Location 3, located near the south runway by the fire station in the Airside area, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 63.2-66.2 dBA, a maximum noise level (L_{max}) between 86.9-97.3 dBA, and a day-night average noise level (L_{dn}) between 67.5-70.9 dBA.

Points Location 4, located in the Ton Kuk community in Moo 7, Suthep Subdistrict, Mueang District, on the west side of the airport, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 58.3-60.3 dBA, a maximum noise level (L_{max}) between 85.3-87.3 dBA, and a day-night average noise level (L_{dn}) between 62.2-63.7 dBA.

Points Location 5, located in the Mae Tia community near the Mae Hia Subdistrict Office in Mueang District, southeast of the airport, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 60.5-62.6 dBA, a maximum noise level (L_{max}) between 88.2-92.1 dBA, and a day-night average noise level (L_{dn})between 63.4-65.9 dBA.

Points Location 6, located in the Umong Village in Suthep Subdistrict, Mueang District, northwest of the airport, recorded a 24-hour average noise level ($L_{eq24\,hr}$) between 59.5-60.2 dBA, a maximum noise level (L_{max}) between 82.6-90.2 dBA, and a day-night average noise level (L_{dn}) between 63.4-64.6 dBA.

The details of the measurement results are summarized in Table 2.

Table 2. Maximum and minimum noise measurement results

No.	Points Location	Distance from Runway (m)	Noise Level dB(A)	
			Min	Max
1	Northern Runway End (Faculty of Agriculture, Chiang Mai University)	1,000	65.9	66.5
2	Passenger Terminal Front Parking Area (Eastern side of Chiang Mai International Airport)	600	61.9	65.2
3	Southern Runway Area in front of Fire Station (Airside Zone)	300	63.2	66.2
4	Ton Kuk Community, Moo 7, Suthep Sub-district, Mueang District, Chiang Mai Province (Western side of Chiang Mai International Airport)	300	58.3	60.3
5	Mae-Hia Community near Mae-Hia Municipality, Mueang District, Chiang Mai Province (Southeastern side of Chiang Mai International Airport)	2,000	60.5	62.6
6	Ban Umong Community, Suthep Sub-district, Mueang District, Chiang Mai Province (Northwestern side of Chiang Mai International Airport)	600	59.5	60.2

3.1.2 Noise Average Level Measurements

Chiang Mai International Airport operates approximately 200 flights daily, serving both incoming and outgoing passengers. The study on noise intensity caused by aircraft involved measurements at six stations, with each station recording the average noise intensity from all aircraft types, as shown in Table 3. It was found that the highest average noise intensity occurred at Points Location 1 (66.2 dB(A)), located at the northern end of the runway near the Faculty of Agriculture at Chiang Mai University. This station recorded the highest levels because it is located close to the flight path, where aircraft require maximum engine power during take-off.

From the data collected at all six stations, the researcher chose to use the 24-hour average noise level ($L_{eq24\,hr}$), as it provides the most comprehensive data. In a week (seven days), this data reflects a complete round of aircraft take-off and landings. The highest noise levels were not selected because their values are less reliable, as the highest noise events could be caused by only a few aircraft during a single hour. The results of the 24-hour average noise measurements from all 6 points location show that the noise level is closely related to the distance from the runway and the aircraft's take-off and landing paths. Points location closer to the runway and within the flight path experience higher noise impacts, as do areas with higher frequencies of runway usage. This is demonstrated in Table 3 and can be used to create a noise level contour map around Chiang Mai International Airport, showing the distribution pattern of the noise levels as shown in Figure 5.

Table 3. Average noise level.

No.	Points Location	Distance from Runway (m)	Noise Level dB(A)
1	Northern Runway End (Faculty of Agriculture, Chiang Mai University)	1,000	66.2
2	Passenger Terminal Front Parking Area (Eastern side of Chiang Mai International Airport)	600	62.7
3	Southern Runway Area in front of Fire Station (Airside Zone)	300	64.5
4	Ton Kuk Community, Moo 7, Suthep Sub-district, Mueang District, Chiang Mai Province (Western side of Chiang Mai International Airport)	300	59.1
5	Mae-Hia Community near Mae-Hia Municipality, Mueang District, Chiang Mai Province (Southeastern side of Chiang Mai International Airport)	2,000	60.9
6	Ban Umong Community, Suthep Sub-district, Mueang District, Chiang Mai Province (Northwestern side of Chiang Mai International Airport)	600	59.8

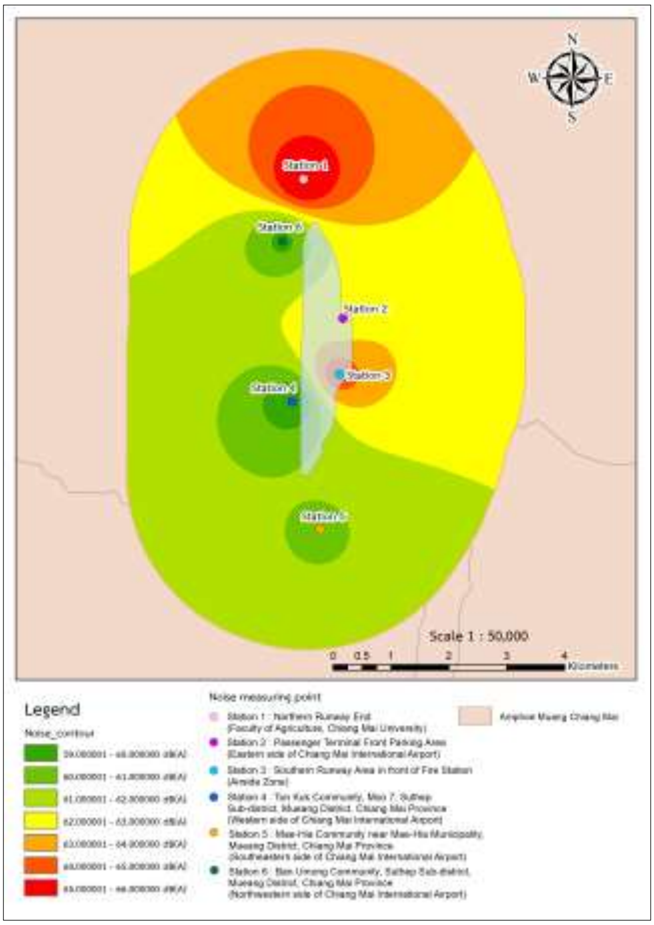

Figure 5. Average Noise Level Contours Around Chiang Mai International Airport

3.2 Results of The Weighted Equivalent Continuous Perceived Noise Level index (ICAO)

Flight frequency during the day was measured from 07:00 to 07:00 the following day. During the study period, the total aircraft movements (N) using the runway amounted to 200 flights per day, including both commercial and cargo aircraft (ICAO, 2016; FAA, 2021). It was assumed that each aircraft movement generated noise for a duration of 60 seconds. The highest calculated WECPNL index of 70.7 was recorded at the northern runway threshold (Faculty of Agriculture, Chiang Mai University), despite being 1,000 meters away from the runway. This high reading was due to its location directly under the aircraft takeoff-landing path and being a point where aircraft require maximum engine power during takeoff (Airports Authority of Thailand, 2020). The second highest readings were recorded at the southern runway area near the fire station (69.0 WECPNL) and the passenger terminal parking area (67.2 WECPNL). Meanwhile, surrounding communities exhibited lower WECPNL index values, particularly the Ton Kuk community, which recorded the lowest value (63.6 WECPNL) despite being only

300 meters from the runway. This lower reading was attributed to its location alongside the runway rather than directly under the aircraft takeoff-landing path (Pollution Control Department, 2020; Office of Natural Resources and Environmental Policy and Planning, 2021), as shown in Table 4.

Table 4. WECPNL index (ICAO) at each location.

No.	Points Location	Noise Level dB(A)			WECPNL
		Min	Max	Average	
1	Northern Runway End (Faculty of Agriculture, Chiang Mai University)	65.9	66.5	66.2	70.7
2	Passenger Terminal Front Parking Area (Eastern side of Chiang Mai International Airport)	61.9	65.2	62.7	67.2
3	Southern Runway Area in front of Fire Station (Airside Zone)	63.2	66.2	64.5	69.0
4	Ton Kuk Community, Moo 7, Suthep Sub-district, Mueang District, Chiang Mai Province (Western side of Chiang Mai International Airport)	58.3	60.3	59.1	63.6
5	Mae-Hia Community near Mae-Hia Municipality, Mueang District, Chiang Mai Province (Southeastern side of Chiang Mai International Airport)	60.5	62.6	60.9	65.4
6	Ban Umong Community, Suthep Sub-district, Mueang District, Chiang Mai Province (Northwestern side of Chiang Mai International Airport)	59.5	60.2	59.8	64.3

3.3 Environmental Noise Status Assessment

The environmental noise assessment from aircraft operations at Chiang Mai Airport in this research utilized the WECPNL (Weighted Equivalent Continuous Perceived Noise Level) index, comparing measured noise levels against established standards. According to the International Civil Aviation Organization standards (ICAO, 2018), areas with WECPNL ≤ 70 are considered suitable for residential use, while areas with WECPNL 70-75 may experience moderate noise impacts and require mitigation measures. Areas with WECPNL > 75 are considered heavily impacted and unsuitable for residential use. Similarly, the Pollution Control Department (2021) sets comparable standards, where areas with WECPNL ≤ 70 are suitable for residential properties, educational institutions, and religious establishments, areas with WECPNL 70-75 require land use controls, and areas with WECPNL > 75 are deemed unsuitable for residential use.

The noise level measurements from all 6 points location around Chiang Mai Airport revealed that Points Location 1 (Northern Runway End (Faculty of Agriculture, Chiang Mai University)) recorded a WECPNL value of 70.7, slightly exceeding the standard and falling within the range requiring land use control measures. The other noise measuring point (Points Location 2-6) recorded WECPNL values between 63.6-69.0, which are within standard limits and suitable for residential use.

Overall, most areas surrounding Chiang Mai Airport maintain noise levels within standard limits, except for the northern runway threshold area, which slightly exceeds the standard. This area should be subject to land use control measures and noise impact mitigation to protect nearby communities (Office of Natural Resources and Environmental Policy and Planning, 2021). Since exceeding noise standards directly influences zoning decisions, urban planners should adopt tiered zoning restrictions based on noise contour maps, ensuring land-use compatibility. Specifically, areas within the 70+ WECPNL zone should be allocated for industrial or commercial purposes rather than residential development, while buffer zones should be designated to prevent the encroachment of noise-sensitive uses.

In addition, corridor-based planning approaches that account for flight path orientations are recommended, directing urban growth away from primary flight corridors and encouraging noise-compatible developments along these paths. Furthermore, the observed correlation between noise levels and distance from runways supports the use of graduated development density controls, whereby building heights and population densities decrease progressively with closer proximity to the airport.

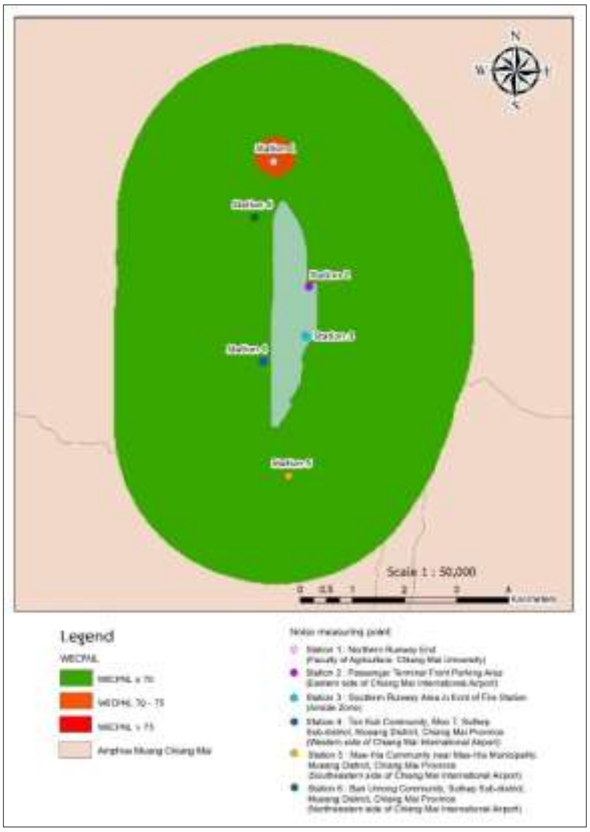

Figure 6. the WECPNL Noise Level Map Around Chiang Mai International Airport

3.4 Airport Development Policy Recommendations

The study's findings necessitate comprehensive policy frameworks that integrate noise management into airport expansion planning. Current airport development policies should incorporate mandatory noise impact assessments for any runway extensions, terminal expansions, or changes in flight operations. The WECPNL methodology demonstrated in this study should be standardized as a requirement for all major airport development projects in Thailand, ensuring consistent assessment criteria across different airports.

Policy frameworks should also address the economic implications of noise-induced land use restrictions. Compensation mechanisms for affected communities and incentive programs for noise-compatible development should be established. This includes tax incentives for businesses willing to locate in higher noise zones and community benefit programs funded through airport revenue sharing.

4. Conclusion

This study analyzed aircraft noise impacts at Chiang Mai International Airport using the WECPNL (Weighted Equivalent Continuous Perceived Noise Level) index as the primary indicator for noise level assessment. The findings revealed that most areas surrounding the airport-maintained noise levels within the standards established by the International Civil Aviation Organization and Thailand's Pollution Control Department. However, Points Location 1 at the Northern Runway End (Faculty of Agriculture, Chiang Mai University) or northern runway threshold recorded a WECPNL value of 70.7, slightly exceeding the standard limit. This area falls into a zone requiring land use control measures and noise impact mitigation to prevent health issues and protect the well-being of nearby residents.

Furthermore, the spatial analysis approach using Inverse Distance Weight (IDW) effectively enabled the creation of noise distribution maps around the airport area. This study's results provide insights into noise distribution patterns and can serve as guidelines for future airport noise management policies, including the implementation of noise mitigation measures such as flight path modification, land use zoning, and aircraft noise reduction technology development. These measures aim to comply with international standards while minimizing impacts on the quality of life of communities surrounding the airport.

5. Acknowledgements

The researchers would like to express their gratitude to their corresponding author for their guidance, as well as the Department of Civil Engineering, Faculty of Engineering, Chiang Mai University, for their support in successfully completing this research.

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