

AN EVALUATION OF THE AIRPORT NOISE AROUND AIRPORT OF THAILAND USING AVIATION ENVIRONMENTAL DESIGN TOOL

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ABSTRACT: Aircraft noise is a significant environmental impact associated with airport operations, affecting both the quality of life in surrounding communities and influencing land use. This paper presents a modeling framework for evaluating the impacts of airport noise around Thailand's major airports. The proposed framework consists of 2 components: 1) Noise impact analysis, to evaluate the exposure patterns of aircraft noise using the Aviation Environmental Design Tool (AEDT) mathematical model, which is a GIS-based analytical approach enriched with historical noise measurement data and aircraft operational characteristics, to forecast Noise Exposure Forecast (NEF) contours, and 2) Temporal comparative analysis using statistical correlation and GIS optimization to evaluate changes in noise-affected zones. The model was validated at 5 major airports, including Suvarnabhumi, Don Mueang, Chiang Mai, Chiang Rai, and Phuket airports. The results of noise impact assessments, which consider accessibility and land use compatibility of communities around airports, risk exposure patterns and population distribution can be reliably determined. At the national level, 363,800 people are affected by aircraft noise, with 57,330 people living in high-impact zones. Validation results show high correlation ($R^2 = 0.89-0.94$) between measured and predicted values. The findings support integrating noise assessment into airport planning, especially for future projects like Chiang Mai Airport No.2, and recommend adopting ICAO-based land use controls to protect communities.

Keywords: Aircraft Noise, Aviation Environmental Design Tool (AEDT), Noise Exposure Forecast (NEF), Land Use Planning

1. INTRODUCTION

Thailand's aviation sector has experienced unprecedented growth over the past decade, emerging as a critical component of Southeast Asia's transportation hub strategy [1]. Following the post-COVID-19 recovery, the sector has demonstrated remarkable resilience with flight volumes increasing 15-20% annually during 2022-2023, significantly exceeding pre-pandemic levels [2]. This rapid expansion has positioned Thailand as a regional aviation leader, with five major airports currently handling over 140 million passengers annually and projections indicating potential doubling of flight operations by 2035 [3].

However, this aviation boom has intensified environmental challenges, particularly aircraft noise pollution, which has emerged as a critical constraint to sustainable airport development [4]. Current estimates indicate that approximately 363,800 people across Thailand's major airports are exposed to significant aircraft noise, with 57,330 people living in high-impact zones (NEF > 40) where noise levels severely affect quality of life [5]. The problem is particularly acute around densely populated airports such as Suvarnabhumi International Airport, Don Mueang, Chiang Mai, and Phuket, where expanding noise footprints increasingly conflict with urban development and residential areas [6,7].

Aircraft noise creates multidimensional impacts including sleep disturbance, elevated stress, reduced cognitive performance, and property value depreciation [8,9]. WHO and ICAO have established clear links between prolonged noise exposure and cardiovascular disease, hypertension, and mental health disorders [4,10].

Thailand's reactive approach to noise management has significant gaps compared to international best practices, resulting in community conflicts, costly retrofitting, and airport expansion limitations [11,12,13]. The lack of standardized assessment protocols and coordinated land use planning threatens sustainable aviation growth [14].

This challenge is critical as Thailand advances major airport expansion projects including Chiang Mai Airport No.2, Andaman International Airport, and facilities in eastern provinces [15]. Without proactive noise management frameworks, these projects risk replicating existing problems [16].

The Aviation Environmental Design Tool (AEDT), developed by the Federal Aviation Administration (FAA), represents the international gold standard for aircraft noise modeling and impact assessment [13]. However, airport noise impacts in Thailand exhibit context-specific characteristics that should be carefully considered in national-level planning and assessment frameworks [17].

Therefore, this research is critical in applying the AEDT tool to evaluate and analyze aircraft noise pollution levels in airport areas, particularly in regions with planned new airport development projects and to examine temporal changes in noise-affected areas using statistical and spatial analysis.

2. RESEARCH SIGNIFICANCE

The significance of this research lies in advancing airport noise assessment practice by providing a validated, national-scale application of the Aviation Environmental Design Tool (AEDT) integrated with GIS-based spatial and temporal analysis. This research extends the state of the art by systematically verifying AEDT performance across multiple airport contexts using empirical noise measurement data. Furthermore, the study contributes to the state of practice by linking noise exposure outcomes with population distribution and ICAO land use compatibility criteria, thereby offering a practical decision-support framework for sustainable airport planning and future airport development projects in Thailand and comparable emerging aviation regions.

3. METHODOLOGY

This study aims to evaluate aircraft noise impacts around airports using the Aviation Environmental Design Tool (AEDT) through quantitative analysis processes comprising 5 main steps. Thus, the methodological framework guide to achieve the objectives of this research was presented in Fig 1.

3.1 Data Assessment and Verification

Relevant data associated with flight operations and aircraft noise levels were systematically collected and validated. This included aircraft noise level data expressed in decibels, flight path information such as Standard Instrument Departures (SID), Standard Terminal Arrival Routes (STAR), and Instrument Approach Charts, as well as air traffic statistics comprising aircraft types, time of operations, and prevailing wind directions. All datasets were rigorously verified and organized to serve as input parameters for the subsequent aircraft noise simulation process.

3.2 Model Development

The assessment of forecasted aircraft noise levels in the form of Noise Exposure Forecast (NEF) contours was conducted using the mathematical simulation model known as the Aviation Environmental Design Tool (AEDT). AEDT is a modeling tool developed by the Federal Aviation Administration (FAA) for predicting aircraft noise and emissions. The tool is capable of generating various types of forecasted noise contours, including

NEF, Day-Night Average Sound Level (DNL), and Effective Perceived Noise Level (EPNL), as well as estimating aircraft-related air pollutant emissions such as VOCs, SO₂, and NO_x. AEDT was developed as an integration of the earlier INM (Integrated Noise Model) and EDMS (Emissions and Dispersion Modeling System), with enhancements including the incorporation of a Geographic Information System (GIS) database for improved usability.

The AEDT system consists of 3 primary data:

- 1) Study Database: This database contains the project-specific input data in the AEDT Standard Input File (ASIF) format. These files are organized as XML files (ASIFXML) and include essential information such as the geographical location of the airport, flight paths, case study parameters, community locations, study boundaries, and flight schedule data throughout the year.
- 2) Airport Database: This database comprises infrastructure information of the airport, including the official airport names according to ICAO and ATA codes, meteorological data, geospatial coordinates of runways and surrounding airport facilities.
- 3) Fleet Database: This includes technical and operational information about aircraft types and engine performance, compiled from international standard sources such as the ICAO Engine Emissions Databank (EDB), the ICAO Aircraft Noise and Performance (ANP) Database, and the Eurocontrol Base of Aircraft Data (BADA).

The Aviation Environmental Design Tool employs the Noise Exposure Forecast (NEF) metric, which integrates both noise level and frequency of exposure over annual operations following FAA technical specifications [13], as shown in Eq. (1)

$$NEF = EPNL + 10\log_{10}(N_d) + 10\log_{10}(N_n) - 88 \quad (1)$$

Where, EPNL = Effective Perceived Noise Level (dB)
 N_d = Daytime operations (07:00-22:00)
 N_n = Nighttime operations (22:00-07:00)
 88 = Normalization constant

3.3 Model Validation & Calibration

Statistical validation employs multiple metrics ensuring reliability against field measurements [18], as shown in Eq. (2)

$$R^2 = 1 - (SS_{res} / SS_{tot}) \quad (2)$$

Where, $SS_{res} = \sum (NEF_{measured} - NEF_{predicted})^2$
 $SS_{tot} = \sum (NEF_{measured} - NEF_{mean})^2$

Acceptable criteria: $R^2 \geq 0.85$, $RMSE \leq 3.0$ dB, $|MBE| \leq 1.5$ dB following international aviation noise modeling standards [19].

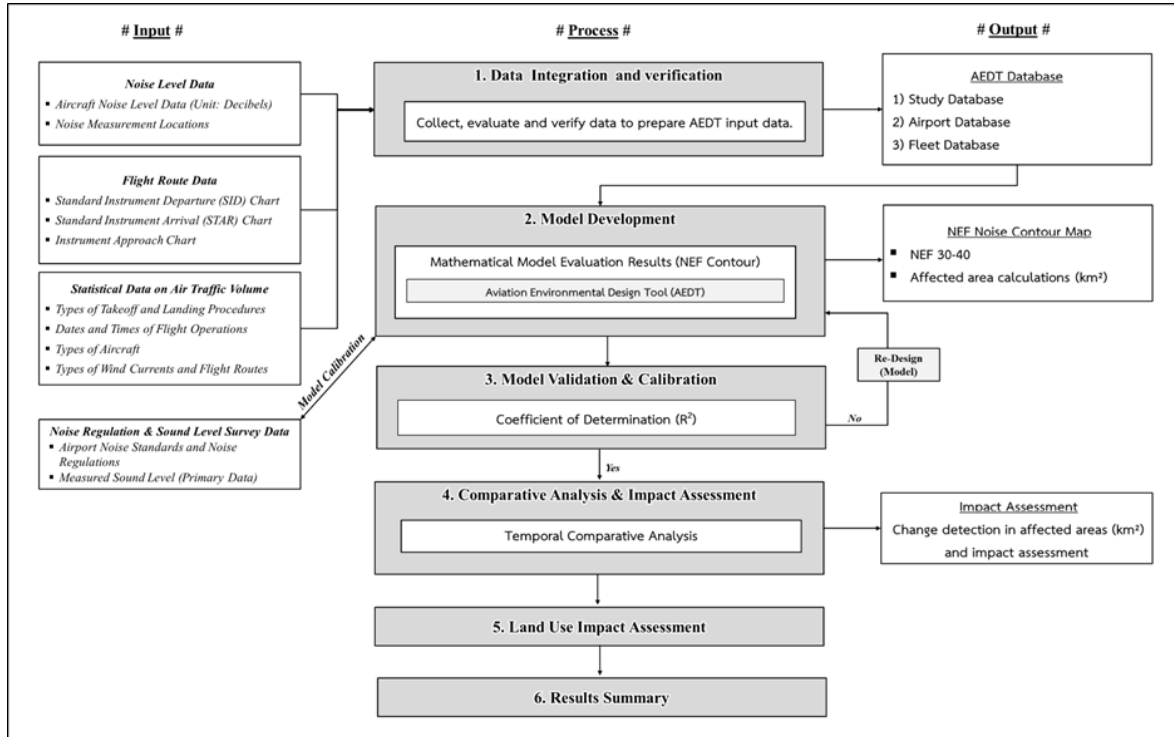


Fig 1. Methodological framework of developing airport noise assessment using AEDT

3.4 Comparative Analysis & Impact Assessment

A spatial comparison was performed by overlaying the NEF contours from two different years onto aerial imagery to analyze changes in the noise contour boundaries. These changes reflect variations in the number of daily flight operations as well as the overall spatial extent of the noise-affected areas.

The analysis considered forecasted noise exposure contours based on the standards recommended by the International Civil Aviation Organization (ICAO), which provide land use guidelines for different NEF levels as follows:

- NEF less than 30: This area is considered unaffected by aircraft noise and is generally suitable for all types of land use.
- NEF 30-35: Aircraft noise in this area causes a low level of disturbance. Mitigation measures are recommended, such as installing sound insulation materials or air-conditioning systems in residential buildings.
- NEF 35-40: This area experiences a moderate level of noise disturbance. Appropriate noise mitigation strategies should be implemented.
- NEF greater than 40: This area is subject to severe aircraft noise impact. Land acquisition or compensation measures may be necessary to address the adverse effects on residents and land use.

Quantitative assessment of noise contour evolution using GIS analysis techniques based on established spatial analysis methodologies [20], as shown in Eq. (3)

$$Relative\ Chang\ (\%) = \frac{Value\ after - Value\ before}{Value\ before} \times 100 \quad (3)$$

Where, Value_{after} = the value in the later year
Value_{before} = the value in the earlier year

Statistical significance testing employs two-sample t-test with $\alpha = 0.05$ significance level according to environmental monitoring protocols [21].

3.5 Land Use Impact Assessment

ICAO Annex 16 compatibility assessment with population impact calculation following established environmental assessment guidelines [22], as shown in Eq. (4)

$$PI = \sum(\rho_i \times A_i \times PIF_i) \quad (4)$$

Where, PI = Population Impact index
 ρ = population density (persons/km²)
A = affected area (km²)
PIF = Population Impact Factor

3.6 Results Summary

The summary of simulation results and impact analysis in both spatial and quantitative aspects was developed using the AEDT database and noise contour maps, which delineate affected areas in square kilometers. These outputs serve as tools to support evidence-based policy decision-making.

4. CASE STUDY

This study selected 5 major airports in Thailand, each with distinct physical contexts, operational characteristics, and surrounding land-use patterns, as case studies for evaluating aircraft noise impacts using the Aviation Environmental Design Tool (AEDT). The simulation results were compared with actual noise measurement data, and spatial trends in noise impacts were analyzed. The selected airports are:

- Suvarnabhumi Airport (BKK): Located in Bang Phli District, Samut Prakan Province.
- Don Mueang Airport (DMK): Located in Don Mueang District, Bangkok.
- Chiang Mai International Airport (CNX): Located in Mueang Chiang Mai District, Chiang Mai Province.
- Mae Fah Luang - Chiang Rai International Airport (CEI): Located in Mueang Chiang Rai District, Chiang Rai Province.
- Phuket International Airport (HKT): Located in Thalang District, Phuket Province.

5. RESULTS

The results of the development and application of models with the case study were as follows:

5.1 Aircraft Noise Impact Assessment Results Using AEDT Model

Based on the generation of aircraft noise contours using actual flight operation data during the noise monitoring period, the mathematical model Aviation Environmental Design Tool (AEDT) was employed. The air traffic data from each airport was processed in the model to forecast daily aircraft noise levels. This process produced NEF (Noise Exposure Forecast) contour maps, as well as correlation values between the measured NEF levels and the NEF values simulated by the AEDT for each airport, as summarized below.

5.1.1 Noise Contour Simulation Results

Mathematical model assessment results in the form of Noise Exposure Forecast (NEF) contours, evaluated from flight situation data from January 1, 2023, to December 31, 2023. A summary of the affected areas within NEF 30-40 and NEF>40 zones was shown in Table 1 and Fig 2.

The results indicate a direct association between operational intensity and the spatial extent of noise impact. Suvarnabhumi Airport records the largest noise-affected area, followed by Don Mueang and Phuket airports, confirming the sensitivity of the model to variations in flight operation volume across different airport scales.

Table 1 The affected areas according to 2023 flight situations within NEF contours

Airport	Daily Flight Operations	Affected Area (km ²)		
		NEF >40	NEF 30-40	Total
Suvarnabhumi Airport	602	3.89	15.55	19.04
Don Mueang Airport	493	3.05	14.31	17.36
Chiang Mai International Airport	198	1.14	5.09	6.20
Mae Fah Luang - Chiang Rai Airport	34	0.15	0.66	0.81
Phuket Airport	285	1.40	4.91	6.31

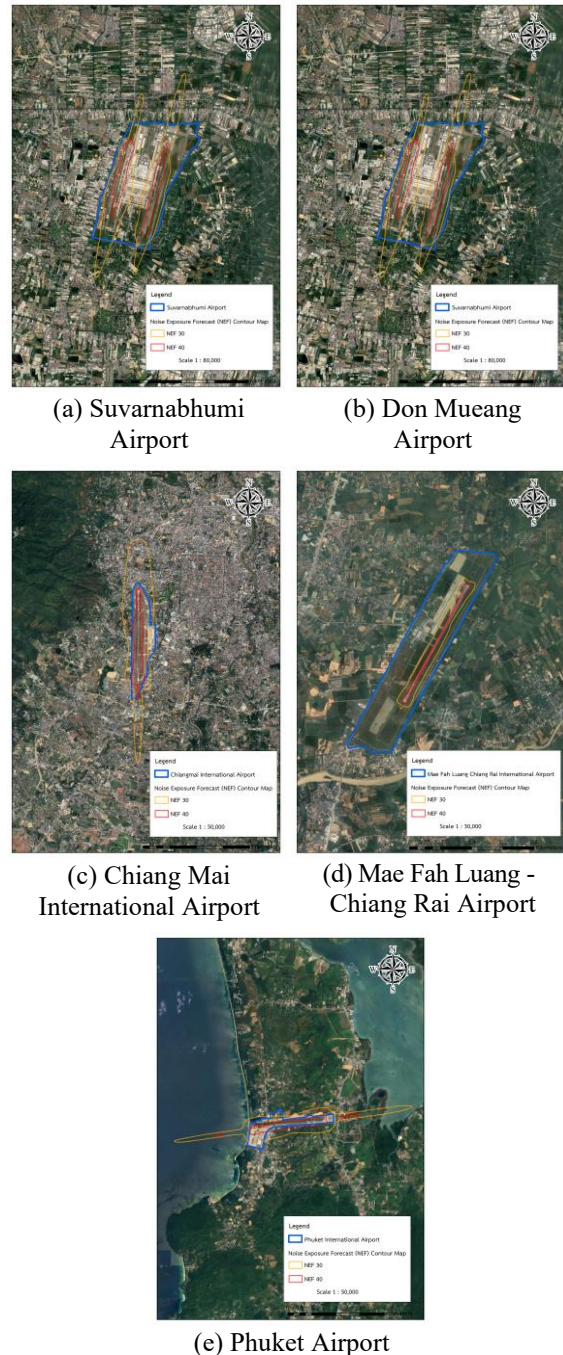


Fig 2. Noise Exposure Forecast (NEF) Contour Map Based on Flight Operations in 2023

5.1.2 Model Validation Results

To evaluate of the Aviation Environmental Design Tool (AEDT) in predicting aircraft noise levels, a comparative analysis was conducted between the Noise Exposure Forecast (NEF) values obtained from actual sound level measurements and those simulated by the AEDT model, using synchronized dates and times at each airport.

The analysis revealed that the correlation coefficients (R^2) between the measured NEF values and those generated by the model ranged from 0.89 to 0.94, indicating a high level of accuracy in AEDT's noise simulation performance within the context of Thai airports. Detailed results were shown in Table 2.

Table 2 Model Validation of AEDT and actual sound level measurements

Airport	Average NEF (Measured)	Average NEF (AEDT)	Correlation Coefficients (R^2)	RMSE (dB)
Suvarnabhumi Airport	32.4	33.1	0.92	2.1
Don Mueang Airport	31.8	32.3	0.89	2.8
Chiang Mai International Airport	28.7	29.2	0.94	1.9
Mae Fah Luang – Chiang Rai Airport	25.3	25.8	0.91	2.3
Phuket Airport	29.6	30.1	0.90	2.5

Note: All correlation coefficients exceed acceptable threshold of $R^2 \geq 0.85$; RMSE values meet criterion of ≤ 3.0 dB

The validation metrics confirm AEDT's reliability for Thailand airport applications. The highest accuracy was observed at Chiang Mai International Airport ($R^2=0.94$), likely attributable to its single-runway configuration and consistent flight patterns. Conversely, Don Mueang exhibited the lowest correlation ($R^2=0.89$), potentially due to complex traffic interactions from parallel runway operations and varied aircraft mix serving both domestic and international routes.

Table 3 Spatial comparison of NEF affected areas between 2018 and 2023

Airport	Affected Area (km ²)						Change (km ²) (%)		
	2018			2023			2018-2023		
	NEF >40	NEF 30-40	Total	NEF >40	NEF 30-40	Total	NEF >40	NEF 30-40	Total
Suvarnabhumi Airport	3.63	14.87	18.50	3.89	15.55	19.04	0.26 (7.2%)	0.68 (4.6%)	0.54 (2.9%)
Don Mueang Airport	3.56	13.29	16.85	3.05	14.31	17.36	-0.51 (-14.3%)	1.02 (7.7%)	0.51 (3.0%)
Chiang Mai International Airport	0.91	3.36	4.27	1.14	5.09	6.20	0.23 (25.3%)	1.73 (51.5%)	1.93 (45.2%)
Mae Fah Luang - Chiang Rai Airport	0.12	0.53	0.65	0.15	0.66	0.81	0.03 (25.0%)	0.13 (24.5%)	0.16 (24.6%)
Phuket Airport	2.04	6.80	8.84	1.40	4.91	6.31	-0.64 (-31.4%)	-1.89 (-27.8%)	-2.53 (-28.6%)

5.2 Spatial Comparison of Noise Exposure Forecast (NEF) Contour Maps

To examine the temporal dynamics of aircraft noise impact, a comparative assessment was conducted using NEF contour data from 2018 and 2023. The analysis focused on two key exposure thresholds NEF>40 and NEF 30-40 to evaluate the spatial extent of noise-affected areas in square kilometers across five major airports in Thailand. Table 3 presents the quantitative results of this comparison, highlighting both the absolute and percentage changes in noise exposure zones over the five-year period. These changes reflect evolving patterns in flight operations, airport expansions, and surrounding land use, which collectively influence noise propagation and its associated impacts on communities

The results indicate divergent temporal trends associated with post-pandemic recovery and operational adjustments. Northern airports, particularly Chiang Mai International Airport (45.2%) and Mae Fah Luang–Chiang Rai International Airport (24.6%), exhibited substantial expansions in noise-affected areas, consistent with tourism-driven traffic growth. In contrast, Phuket Airport recorded a 28.6% reduction in its noise footprint, suggesting the effectiveness of operational optimization measures and preferential flight routing implemented during the study period.

5.3 Land Use Impact Assessment

Analysis results indicate several critical findings regarding airport noise impacts and their implications for land use planning based on ICAO Annex 16 guidelines and international best practices for sustainable airport development [22,25], as shown in Table 4.

Table 4 Population impact assessment based on ICAO land use compatibility

Airport	Population in NEF >40 (persons)	Population in NEF 30-40 (persons)	Total Affected Population	Land Use Index
Suvarnabhumi Airport	23,340	124,400	147,740	0.67
Don Mueang Airport	18,300	115,000	133,300	0.62
Chiang Mai International Airport	6,840	35,630	42,470	0.71
Mae Fah Luang – Chiang Rai Airport	450	1,980	2,430	0.81
Phuket Airport	8,400	29,460	37,860	0.74

The Land Use Compatibility Index highlights pronounced spatial conflicts between airport operations and surrounding residential development. Metropolitan airports, including Suvarnabhumi airport index 0.67 and Don Mueang airport index 0.62, exhibit lower compatibility values, indicating a higher proportion of incompatible land uses within noise-affected zones. In contrast, Mae Fah Luang–Chiang Rai International Airport shows the highest compatibility index 0.81, reflecting lower population density and more appropriate land use patterns around the airport, which contribute to reduced exposure of residential areas to aircraft noise.

6. DISCUSSION

The study demonstrates AEDT's effectiveness in Thai airport contexts, with correlation coefficients ($R^2=0.89-0.94$) meeting international standards [26,30]. Spatial analysis reveals heterogeneous noise impact patterns across different airport types and operational contexts. Chiang Mai International Airport's 45.2% expansion reflects rapid tourism recovery, while Phuket Airport's 28.6% reduction suggests effective operational optimization [23,24]. These results confirm that AEDT reliably captures both growth-driven and mitigation-driven changes in airport noise exposure.

Population impact analysis indicates 363,800 persons affected by airport noise nationally, with 57,330 in high-impact zones requiring immediate attention. This substantial exposure underscores the urgency for comprehensive noise management strategies following ICAO guidelines [22,25]. The findings further highlight the importance of integrating population exposure metrics into environmental decision-making to support transparent prioritization of mitigation measures.

From a policy perspective, the validated AEDT framework provides a robust basis for standardized noise assessment and prioritization of mitigation investments across Thailand's airport network. The concentration of population exposure at metropolitan airports, particularly Suvarnabhumi and Don Mueang

airport, indicates that targeted interventions at these facilities would yield the greatest immediate public benefit. Meanwhile, the contrasting trajectories observed at Chiang Mai and Phuket airports demonstrate that operational strategies, such as flight routing and traffic management, can effectively control noise footprints independent of infrastructure expansion. These findings support the integration of AEDT-based noise zoning, operational optimization, and land use coordination into airport master planning and national aviation policy to ensure sustainable airport development.

7. CONCLUSION

This research validates AEDT as an accurate tool for airport noise assessment in Thailand, with a prediction accuracy of $R^2 = 0.89-0.94$. The results indicate that four out of 5 major airports experienced an expansion of noise-affected areas between 2018 and 2023, ranging from 3.0% to 45.9%, with a cumulative affected area of 52.1 km² nationwide. Currently, approximately 363,800 people are exposed to aircraft noise, including 57,330 people within high-impact zones requiring immediate mitigation.

Distinct regional patterns in noise impact evolution were identified. Metropolitan airports exhibit steady growth in noise exposure, northern airports show rapid expansion driven by tourism recovery, and southern airports demonstrate potential for noise reduction through operational optimization. These findings highlight the necessity of integrating aircraft noise assessment into the earliest stages of airport planning, particularly for upcoming projects such as Chiang Mai Airport No.2 and Andaman International Airport. The establishment of mandatory noise impact zones within airport master plans, supported by integrated transportation and land use planning, is essential to mitigate long-term community impacts.

The integration of AEDT-based noise modeling with GIS spatial analysis establishes a replicable and proactive framework for airport planning. Pre-construction noise simulations enable informed decisions on runway orientation, flight path design, and operational strategies, allowing noise mitigation to be incorporated into airport layouts from the initial planning stage. The consistent validation performance across metropolitan, regional, and tourism-oriented airports confirms the feasibility of implementing standardized noise assessment protocols nationwide. When calibrated with local operational data, AEDT provides reliable predictions suitable for regulatory decision-making, land use planning, and stakeholder engagement. Future research should focus on longitudinal validation of temporal forecasts, incorporation of supplementary indicators capturing community noise annoyance, and the development of

adaptive noise management systems linking real-time monitoring with predictive modeling to support sustainable aviation development in Thailand.

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