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Analysis of Noise Distribution from Take-Off and Landing Activities at Haluoleo Airport, Kendari

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ABSTRAK

Bandara Halu Oleo yang dahulu bernama Bandara Wolter Mongisidi terletak di Desa Ambaipua, Kecamatan Ranomeeto, Kabupaten Konawe Selatan, Sulawesi Tenggara dan melayani penerbangan nasional dengan total kedatangan sebanyak 3.103 kali dan keberangkatan sebanyak 3.098 kali pada tahun 2023. Tingginya aktivitas penerbangan tersebut meningkatkan tekanan kebisingan sehingga berdampak pada kesehatan masyarakat dan kenyamanan lingkungan sekitar. Penelitian ini menganalisis tingkat dan sebaran kebisingan di sekitar Bandara Halu Oleo Kendari akibat aktivitas pendaratan dan lepas landas dengan menggunakan indeks Weighted Equivalent Continuous Perceived Noise Level (WECPNL). Metode yang digunakan adalah deskriptif kuantitatif dengan simulasi kontur berbasis perangkat lunak ArcGIS. Penelitian ini mengukur kebisingan di tiga lokasi yaitu area runway, taxiway, dan apron dengan rata-rata WECPNL sebesar 183,63 dB(A) (zona III/tinggi); terminal bandar udara dengan rata-rata WECPNL sebesar 76,80 dB(A) (zona II/sedang); dan kawasan BTN Khalifa Resident dengan rata-rata WECPNL 67,83 dB(A) (zona I/rendah). Berdasarkan Keputusan Menteri Lingkungan Hidup No. Kep.48/MENLH/11/1996, tingkat kebisingan di kawasan bandar udara (60 dB(A)) dan permukiman (55 dB(A)) telah melampaui ambang batas yang diizinkan. Simulasi kontur menunjukkan bahwa Zona III hanya sesuai untuk fasilitas bandar udara; Zona II masih digunakan untuk kegiatan tertentu meskipun melanggar ketentuan. Zona I juga dapat digunakan untuk berbagai kegiatan, kecuali di gedung sekolah dan rumah sakit. Studi ini menyimpulkan bahwa kebisingan di sekitar Bandar Udara Halu Oleo memerlukan pengelolaan yang lebih baik untuk melindungi masyarakat dan lingkungan.

Kata kunci: Kebisingan, Mendarat, Lepas landas, Bandara, Landasan pacu

ABSTRACT

Halu Oleo Airport, formerly known as Wolter Mongisidi Airport, is located in Ambaipua Village, Ranomeeto District, South Konawe Regency, Southeast Sulawesi, and serves national flights with a total of 3,103 arrivals and 3,098 departures in 2023. The high flight activity increases noise pressure, impacting public health and the comfort of the surrounding environment. This study analyses the noise level and distribution around Halu Oleo Airport, Kendari, due to landing and take-off activities using the Weighted Equivalent Continuous Perceived Noise Level (WECPNL) index. The method used is descriptive quantitative, with contour simulation based on ArcGIS software. This study measured noise in three locations: runway, taxiway, and apron areas with an average WECPNL of 183.63 dB(A) (zone III/high); airport terminal with an average WECPNL of 76.80 dB(A) (zone II/moderate); and BTN Khalifa Resident area with an average WECPNL of 67.83 dB(A) (zone I/low). Based on the Decree of the Minister of Environment No. Kep.48/MENLH/11/1996, the noise level in the airport area (60 dB(A)) and settlements (55 dB(A)) exceeded the permitted threshold. Contour simulation shows that Zone III is only suitable for airport facilities; Zone II is still used for certain activities even though it violates regulations. Zone I can also be used for various activities, except in school buildings and hospitals. This study concludes that noise around Halu Oleo Airport requires better management to protect the community and the environment.

Keywords: Noise, Landing, Take Off. Airport, Runway

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1. INTRODUCTION

Halu Oleo Airport was previously called Wolter Mongisidi Airport where the airport is located in Ambaipua Village, Ranomeeto District, South Konawe Regency, Southeast Sulawesi Province, which is managed by the Halu Oleo Airport Service Unit (UPBU). Southeast Sulawesi, which serves national flight routes, has a runway length of 2,500 m and a width of 45 meters to accommodate wide aircraft, such as Boeing 737-900ER and Airbus A320 planes.

Statistical data on air transportation in Southeast Sulawesi Province using Halu Oleo Airport in 2023 shows the number of flights reaching 3,103 for arrivals and 3,098 for departures. The increase in the number of flights can cause an increase in noise levels from landing and take-off activities around the airport (Herawati, 2016: Rachman, 2007). Based on the Decree of the Minister of Environment No. 48 of 1996 concerning Noise Level Standards, noise is unwanted from a business or activity at a certain time, which can cause problems with human health and environmental comfort (Novianto et al., 2023; Zeng et al., 2024).

The increasing need for air transportation services is very large in line with the relatively large population and the increase in community welfare. Air transportation has a dominant role, especially in the need for short space. High activity levels from transportation facilities can cause high sound pressure or noise (Basner et al., 2017). The public's need for air transportation also impacts on the noise aircraft engines produce during landing and take-off in residential areas around airports. The negative influence of continuous noise from airport activities is very broad and has an impact on behaviour in the form of physiological and psychological effects (Ramadhan et al., 2018).

One crucial consideration for housing developments near airports is the establishment of designated noise zones to ensure community well-being and compliance with environmental standards (Novianto et al., 2023). Accordingly, analyzing noise levels is imperative to determine whether residential areas surrounding Halu Oleo International Airport fall within the prescribed noise zones and adhere to the acceptable thresholds for habitation. This analysis follows the guidelines and indices stipulated in PP 40 of 2012 regarding the Development and Preservation of the Airport Environment, employing the Weighted Equivalent Continuous Perceived Noise Level (WECPNL) recommended by the International Civil Aviation Organization (ICAO) (Nofriandi et al., 2018). This study holds significant importance as it aims to comprehensively analyze the noise levels using the WECPNL index and evaluate the noise distribution around Halu Oleo Airport, providing essential insights for mitigating noise impacts and safeguarding the health and comfort of the nearby community.

2. METHODS

The research location is Halu Oleo Airport, where the airport is in Ambaipua Village, Ranomeeto District, South Konawe Regency, Southeast Sulawesi Province.

This research period was one month from preparation to completion, from March 2 to 30, 2023. With measurement times starting at 06.00 WITA until 18.00 WITA for three days (Thursday, Friday, and Saturday) with the distribution of measurement times as follows:

N1 : Number of aircraft landing and take-off from 00.00 – 07.00 WITA
N2 : Number of aircraft landing and take-off from 00.07 – 19.00 WITA
N3 : Number of aircraft landing and take-off from 19.00 – 22.00 WITA
N4 : Number of aircraft landing and take-off from 22.00 – 00.00 WITA

A calculation is needed to determine the amount of noise at the airport based on the number of plane arrivals per day. So, this noise analysis is calculated based on the Government of the Republic of Indonesia Regulation No. 40 of 2012 concerning the Development and Preservation of the Airport Environment, explaining that the index used in measuring noise areas is the WECPNL (Weighted Equivalent Continuous Perceived Noise Level) index. The steps for calculating noise at airports are as follows:

1. Determine the basics of calculations, namely:
   a. Number of flights and arrivals in a day for one-week
   b. Aircraft type
2. Calculation of the amount of noise at the airport using the method:
   a. The average dB (A) (decibel value) of peak aircraft activity in a day.
   b. Number of Weighted Equivalent Continuous Perceived Noise Levels (WECPNL).
   c. Number N (Number of aircraft arrivals and departures in 24 hours.

3. RESULTS AND DISCUSSION

Determining the location of the measuring points was carried out at three data collection points in the area around Haluoleo Kendari Airport, namely the first point in the runway, taxiway and apron area of Haluoleo Kendari Airport, the second point in the Haluoleo Kendari Airport terminal area and the third point in the BTN Khalifa Resident residential area. The location of the data collection measuring points in the area around Haluoleo Kendari Airport is in Figure 1.

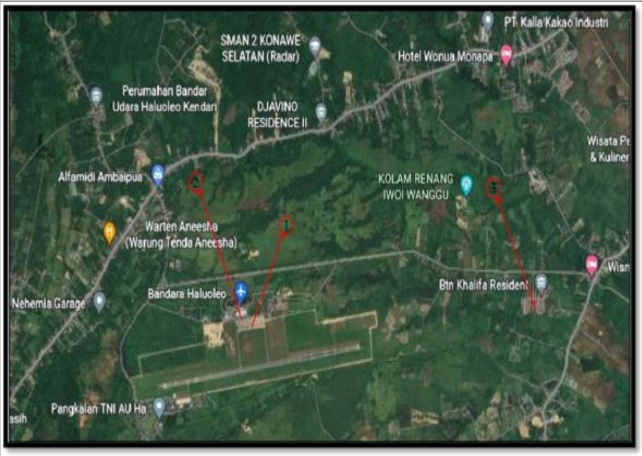

Figure 1. Sampling Location Points

Table 1. Noise Data on the Haluoleo Airport Runway

Flight Number	Airline	Time	Runway Noise Level (dB)	
			L/D	T/O
JT 991	Lion Air	07.04		74,2
JT 986	Lion Air	08.55	72,0	
JT 986	Lion Air	09.41		72,6
QG 333	Citilink	07.58		78,4
GA 604	Garuda	09.22	74,3	
GA 605	Garuda	10.20		71,2
CR 757	Cargo	09.41	71,4	
CR 758	Cargo	11.04		74,6
JT 992	Lion Air	12.30	73,5	
JT 995	Lion Air	13.32		77,7
ID 6742	Batik Air	12.52	73,5	
ID 6723	Batik Air	13.39		84,0
ID 6722	Batik Air	15.09	75,2	
ID 6725	Batik Air	15.54		77,1
JT 994	Lion Air	16.03	70,2	
JT 997	Lion Air	16.39		71,1
QG 330	Citilink	17.08	72,6	
QG 331	Citilink	17.41		81,0
QG 332	Citilink	20.00	73,5	
JT 996	Lion Air	20.13	71,2	

Source: Primary Data 2023

Table 2. Noise Data on Haluoleo Airport Taxiway

Flight Number	Airline	Time	Runway Noise Level (dB)	
			L/D	T/O
JT 991	Lion Air	07.04		72.3
QG 333	Citilink	07.58		74.7
JT 986	Lion Air	08.55	74.3	
JT 986	Lion Air	09.41		73.7
GA 604	Garuda	09.22	72.6	
GA 605	Garuda	10.20		75.7
CR 757	Cargo	09.41	73.6	
CR 758	Cargo	11.04		78.3
JT 992	Lion Air	12.30	75.8	
JT 995	Lion Air	13.32		75.3
ID 6742	Batik Air	12.52	74.1	
ID 6723	Batik Air	13.39		70.6
ID 6722	Batik Air	15.09	72.5	
ID 6725	Batik Air	15.54		74.6
JT 994	Lion Air	16.03	76.8	
JT 997	Lion Air	16.39		70.3
QG 330	Citilink	17.08	73.8	
QG 331	Citilink	17.41		72.5
QG 332	Citilink	20.00	71.6	
JT 996	Lion Air	20.13	73.8	

Source: Primary Data 2023

After collecting data at the Kendari Haluoleo Airport location in the Runway, Taxiway and Apron areas for one day of measurements, noise data was obtained as follows in Table 1.

From Table 1, the noise distribution based on activity shows that landing noise levels ranged from 70.2 dB to 75.2 dB, with the highest level recorded at 75.2 dB for flight ID 6722 (Batik Air) at 15:09. Some flights did not have landing noise recordings, possibly because they were taking off or measurements were not taken during landing. On the other hand, takeoff noise levels ranged from 71.1 dB to 84.0 dB, with the highest level of 84.0 dB observed for flight ID 6723 (Batik Air) at 13:39. As expected, takeoff activities generally produce higher noise levels due to the greater engine thrust required. Temporal trends show that morning flights (07:00–10:00) contribute significantly to noise levels, with high noise events such as QG 333 (Citilink) at 07:58 producing 78.4 dB at takeoff and GA 604 (Garuda) at 09:22 producing 74.3 dB at landing. Afternoon flights (12:00–15:00) show peak noise levels, most notably with ID 6723 (Batik Air) at 13:39 reaching 84.0 dB at takeoff and JT 992 (Lion Air) at 12:30 reaching 73.5 dB at landing. Evening flights (16:00–20:00) show reduced but significant noise levels, such as QG 331 (Citilink) at 17:41, producing 81.0 dB at takeoff. The pattern of airlines shows that Batik Air consistently recorded high noise levels, especially during takeoff, which may be due to the characteristics of the aircraft or its larger engines. Lion Air showed moderate noise levels during landing and takeoff, with some flights quieter than average. Citilink also showed consistently high noise levels during takeoff, with values such as 78.4 dB and 81.0 dB. Cargo flights showed relatively moderate noise levels, suggesting using smaller or quieter aircraft. Based on research (Mulyana et al., 2021), noise levels that exceed the established threshold, as seen in the analysis of Haluoleo Airport, are directly correlated with public complaints about noise around Husein Sastranegara Airport.

Based on Table 2, Noise data from Haluoleo Airport shows different patterns based on activity, time, and airline operations. During landing (D/L), noise levels ranged from 71.6 dB to 76.8 dB, with the highest recorded on flight JT 994 (Lion Air) at 16:03. However, some flights did not record noise during landing, possibly because they were taking off or due to data limitations. For takeoff (T/O), noise levels were generally higher, ranging from 70.3 dB to 78.3 dB, with the highest noise recorded on flight CR 758 (Cargo) at 11:04. The increase in noise during takeoff corresponds to the greater engine thrust required. Temporal analysis shows that morning flights (07:00–10:00) contribute significantly to noise levels, with notable examples such as QG 333 (Citilink) at 07:58 producing 74.7 dB and GA 604 (Garuda) at 09:22 producing 72.6 dB upon landing. In the afternoon (12:00–15:00), noise levels peak on flights such as JT 992 (Lion Air) at 12:30, recording 75.8 dB upon landing and ID 6725 (Batik Air) at 15:54, producing 74.6 dB upon takeoff. Night flights (16:00–20:00) showed a slight but still significant decrease in noise, such as JT 994 (Lion Air) at 16:03 with 76.8 dB upon landing and QG 331 (Citilink) at 17:41 with 72.5 dB upon takeoff. Based on the airlines, Lion Air consistently showed moderate to high noise levels during landing and takeoff, with a peak at landing of 76.8 dB. Citilink recorded relatively high noise levels during takeoff, reaching 74.7 dB and 72.5 dB. Batik Air showed moderate noise levels, with a peak at takeoff of 74.6 dB, while cargo flights showed the highest takeoff noise levels, with CR 758 reaching 78.3 dB. The regulatory implications are significant as all recorded noise levels exceed the occupancy threshold of 55 dB(A) as stipulated by the Decree of the Minister of Environment No. Decree 48/MENLH/11/1996. According to Iswandi (2021), take-off activities at Sultan Iskandar Muda Airport tend to produce higher noise levels compared to landings, this is in accordance with the analysis at Haluoleo Airport, where the highest take-off noise was recorded at 78.3 dB for flight CR 758.

From the sampling results on the first day, the noise level caused by aircraft engines was found on Lion Airplanes at 12.30-13.32 WITA, followed by cargo planes at 09.41-11.04 WITA and on Garuda planes at 09.22-10.22 WITA. The apron location tends to be high because the sampling point is at the parking stand apron of the aircraft (Sznajderman et al., 2021). In contrast, the runway and taxiway areas tend to be lower than the apron because the sampling location is further away, so the sample obtained is lower (Jones, 2017). Noise data was obtained by taking data in the Kendari Haluoleo Airport office area for one measurement day.

The noise data from Haluoleo Airport highlights significant variations in noise levels during both landing (D/L) and take-off (T/O) activities, with values exceeding the permissible thresholds for residential and airport areas. Landing noise levels range from 91.5 dB to 103.2 dB, with the highest recorded for flight GA 604 (Garuda) at 09:39, indicating that morning landings are a major contributor to noise pollution. Take-off noise levels range from 79.1 dB to 102.0 dB, with QG 331 (Citilink) at 17:42 producing the highest level. This trend confirms that take-off operations, requiring greater engine thrust, generally produce slightly lower but still significant maximum noise levels compared to landings. Temporal patterns reveal that morning flights (07:00–10:00) contribute the most to noise, with peaks like QG 333 (Citilink) at 07:58 reaching 98.3 dB during take-off and GA 604 (Garuda) at 09:39 reaching 103.2 dB during landing. Afternoon flights (12:00–16:00) sustain high noise levels, such as ID 6724 (Batik Air) at 13:37, reaching 102.1 dB during landing and ID 6725 (Batik Air) at 16:00, producing 96.3 dB during take-off. Evening flights (17:00–21:00) show slightly reduced activity but still significant levels, such as QG 331 (Citilink) reaching 102.0 dB during take-off and Cargogo at 18:36 reaching 100.5 dB during landing. By airline, Garuda and Batik Air exhibit the highest noise levels during landing, peaking above 100 dB, while Citilink consistently generates high noise during take-off. Cargo flights also contribute notably, with a landing noise peak of 100.5 dB. These findings indicate that commercial and Catalogo operations significantly impact noise distribution around the airport. According to Airlangga et al. (2023), at Sultan Thaha Jambi Airport, take-off and landing activities were highlighted as the main contributors to noise, similar to the findings at Haluoleo Airport, where take-offs (e.g., QG 331 (Citilink) at 102.0 dB) and landings (e.g., GA 604 (Garuda) at 103.2 dB) consistently exceeded the permitted threshold.

At this location, there tends to be a higher noise value for aircraft landing activities than for takeoff activities because the aircraft landing route must pass through the aircraft's AirNav location point, and this location is very close to residential areas, so the noise emitted during landing activities is very high in the BTN Khalifa Resident residential area (Ali et al., 2024). Residential areas and airnav points, which are aircraft flight paths, can be seen in Figure 2.

Table 3. Noise Data on the Haluoleo Airport Apron

Flight Number	Airline	Time	Runway Noise Level (dB)
JT 991	Lion Air	07.04	83.6
QG 333	Citilink	07.58	83.5
JT 986	Lion Air	08.55	85.2
JT 986	Lion Air	09.41	86.3
GA 604	Garuda	09.22	86.7
GA 605	Garuda	10.20	91.4
CR 757	Cargo	09.41	88.7
CR 758	Cargo	11.04	90.3
JT 992	Lion Air	12.30	94.3
JT 995	Lion Air	13.32	80.0
ID 6742	Batik Air	12.52	87.5
ID 6723	Batik Air	13.39	79.0
ID 6722	Batik Air	15.09	88.5
ID 6725	Batik Air	15.54	86.1
JT 994	Lion Air	16.03	83.3
JT 997	Lion Air	16.39	82.1
QG 330	Citilink	17.08	85.3
QG 331	Citilink	17.41	83.3
QG 332	Citilink	20.00	85.3
JT 996	Lion Air	20.13	84.6

Source: Primary Data 2023

Table 4. Noise Data in the Haluoleo Airport Office Area

Flight Number	Airline	Time	Runway Noise Level (dB)	
			L/D	T/O
JT 991	Lion Air	07.04		95,3
QG 333	Citilink	07.58		98,3
JT 986	Lion Air	09.10	93,2	
JT 987	Lion Air	09.54		82,2
GA 604	Garuda	09.39	103,2	
GA 605	Garuda	10.35		79,1
JT 992	Lion Air	12.51	91,5	
JT 995	Lion Air	13.37		83,3
ID 6724	Batik Air	13.37	102,1	
ID 6723	Batik Air	14.20		92,4
ID 6722	Batik Air	15.18	98,6	
ID 6725	Batik Air	16.00		96,3
JT 994	Lion Air	16.43	92,5	
JT 997	Lion Air	17.27		83,6
QG 330	Citilink	17.13	94	
QG 331	Citilink	17.42		102
--	Cargo	18.36	100,5	
--	Cargo	19.19		88,5
QG 332	Citilink	19.33	93,5	
JT 996	Lion Air	20.59	93,8	

Source: Primary Data 2023

Table 5. Noise Data in the BTN Khalifa Residence Residential Area

Flight Number	Airline	Time	Runway Noise Level (dB)	
			L/D	T/O
JT 991	Lion Air	07.07		64.8
QG 333	Citilink	07.29		68.2
JT 986	Lion Air	08.52	93.5	
JT 987	Lion Air	10.15		70.3
GA 604	Garuda	09.35	91.1	
GA 605	Garuda	10.28		67.0
--	Executive	10.02	84.6	
--	Executive	16.56		53.2
ID 6724	Batik Air	12.51	91.3	
ID 6723	Batik Air	13.35		63.4
JT 992	Lion Air	13.13	88.2	
JT 995	Lion Air	14.12		58.2
ID 6722	Batik Air	15.09	92.5	
ID 6725	Batik Air	15.44		72.1
--	Cargo	16.01	95.7	
--	Cargo	16.38		69.4
JT 994	Lion Air	16.29	86.8	
JT 997	Lion Air	17.07		62.3
QG 330	Citilink	17.26	84.6	
QG 331	Citilink	17.57		57.3
QG 332	Citilink	19.55	91.3	
JT 996	Lion Air	20.50	94.7	

Source: Primary Data 2023

Figure 2. Location of AirNav Airplane Flight Path

Table 6. Recapitulation of N Number Calculations

Day	Number of Flights in 24 Hours	N1	N2	N3	N4	Total
		00.00-07.00	07.00-19.00	19.00-22.00	22.00-00.00	
1	20	0	17	3	0	81
2	22	0	20	2	0	80
3	20	0	18	2	0	74
Number						235

Source: Primary Data 2023

Table 7. Recapitulation of Decibel Weight Values (A)

No	Sample Location	dB(A)
1	Runway	60.59
2	Taxiway	72.39
3	Apron	74.38
4	Terminal	84.77
5	Residential Area	76.14
	Total	207.37

Source: 2023 Analysis

To get the Number of aircraft landings and takeoffs based on weight (N), namely for N1 = Number of aircraft landings and takeoffs from 00.00 - 07.00 WITA, N2 = Number of aircraft landings and takeoffs from 07.00 - 19.00 WITA, N3 = Number of aircraft landing and takeoff from 19.00 - 22.00 WITA, N4 = Number of aircraft landing and takeoff from 22.00 - 00.00 WITA.

After obtaining noise level data from the measurement results, the measurement data was analysed to get the average decibel weight (A) value for each shoulder of the aircraft during one day of measurement. The measurement results are calculated to bring dB(A):

To get the dB (A) value in Table 7 above, data analysis was first carried out to find the dB (A) value at each location point on the three days of data collection. Therefore, to obtain the dB(A) value, the following calculation analysis is used:

$$dB(A)=10\log\frac{1}{20}\left[\frac{\begin{matrix}10^{0,1\times 72,0}+10^{0,1\times 74,3}+10^{0,1\times 71,4}+10^{0,1\times 73,5}+\\ 10^{0,1\times 73,5}+10^{0,1\times 75,2}+10^{0,1\times 70,2}+10^{0,1\times 72,6}+\\ 10^{0,1\times 73,5}+10^{0,1\times 71,2}+10^{0,1\times 74,2}+10^{0,1\times 78,4}+\\ 10^{0,1\times 72,6}+10^{0,1\times 71,2}+10^{0,1\times 74,6}+10^{0,1\times 77,3}+\\ 10^{0,1\times 84,0}+10^{0,1\times 77,1}+10^{0,1\times 71,1}+10^{0,1\times 81,0}\end{matrix}}{20}\right]$$

dB(A)=60.59

$$dB(A)=10\log\frac{1}{20}\left[\frac{\begin{matrix}10^{0,1\times 74,3}+10^{0,1\times 72,6}+10^{0,1\times 73,6}+10^{0,1\times 75,8}+\\ 10^{0,1\times 74,1}+10^{0,1\times 72,5}+10^{0,1\times 76,8}+10^{0,1\times 73,8}+\\ 10^{0,1\times 71,6}+10^{0,1\times 73,8}+10^{0,1\times 72,3}+10^{0,1\times 74,7}+\\ 10^{0,1\times 73,7}+10^{0,1\times 75,7}+10^{0,1\times 78,3}+10^{0,1\times 75,3}+\\ 10^{0,1\times 70,6}+10^{0,1\times 74,6}+10^{0,1\times 70,3}+10^{0,1\times 72,5}\end{matrix}}{20}\right]$$

dB(A)=72.39

$$dB(A)=10\log\frac{1}{20}\left[\frac{\begin{matrix}10^{0,1\times 85,2}+10^{0,1\times 86,7}+10^{0,1\times 88,7}+10^{0,1\times 94,3}+\\ 10^{0,1\times 87,5}+10^{0,1\times 88,5}+10^{0,1\times 83,3}+10^{0,1\times 85,3}+\\ 10^{0,1\times 85,3}+10^{0,1\times 84,6}+10^{0,1\times 83,6}+10^{0,1\times 83,5}+\\ 10^{0,1\times 86,3}+10^{0,1\times 91,4}+10^{0,1\times 90,3}+10^{0,1\times 80,0}+\\ 10^{0,1\times 79,0}+10^{0,1\times 86,1}+10^{0,1\times 82,1}+10^{0,1\times 83,3}\end{matrix}}{20}\right]$$

dB(A)=74.38

The results of the calculation of the sum of the Haluoleo Airport area for the runway, taxiway and apron areas can be added up because the measurements are carried out at one time and for the same aircraft during landing and takeoff (Zaporozhets et al., 2022). The plane that will land will run through the runway, taxiway and apron and vice versa if the aircraft takeoff passes through the apron, taxiway and runway, the totals are as follows:

dB(A) = Runway +Taxiway + Apron
= 52.9 + 63.26 + 66.08
= 207.37

The results of the dB (A) calculation at the Haluoleo Kendari Airport area can be seen in the equation below:

$$dB(A)=10\log\frac{1}{22}\left[\frac{\begin{matrix}(10^{0,1\times 93,2})+(10^{0,1\times 103,2})+(10^{0,1\times 91,5})+(10^{0,1\times 102,1})+\\ (10^{0,1\times 98,6})+(10^{0,1\times 92,5})+(10^{0,1\times 94,0})+(10^{0,1\times 100,5})+\\ (10^{0,1\times 93,5})+(10^{0,1\times 93,8})+(10^{0,1\times 95,3})+(10^{0,1\times 93,7})+\\ (10^{0,1\times 87,8})+(10^{0,1\times 98,7})+(10^{0,1\times 83,3})+(10^{0,1\times 99,8})+\\ (10^{0,1\times 96,3})+(10^{0,1\times 87,4})+(10^{0,1\times 102,0})+(10^{0,1\times 105,2})\end{matrix}}{22}\right]$$

dB(A)=84.7

The dB (A) calculation results at the BTN Khalifa Resident Housing area point can be seen in the equation below:

$$dB(A)=10\log\frac{1}{20}\left[\frac{\begin{matrix}10^{0,1\times 93,5}+10^{0,1\times 91,1}+10^{0,1\times 84,6}+10^{0,1\times 91,3}+\\ 10^{0,1\times 88,2}+10^{0,1\times 92,5}+10^{0,1\times 95,7}+10^{0,1\times 86,8}+\\ 10^{0,1\times 84,6}+10^{0,1\times 91,3}+10^{0,1\times 94,7}+10^{0,1\times 64,8}+\\ 10^{0,1\times 68,2}+10^{0,1\times 70,3}+10^{0,1\times 67,0}+10^{0,1\times 53,2}+\\ 10^{0,1\times 63,4}+10^{0,1\times 58,2}+10^{0,1\times 72,1}+10^{0,1\times 69,4}+\\ 10^{0,1\times 62,3}+10^{0,1\times 57,3}\end{matrix}}{20}\right]$$

dB(A)=76.1

After obtaining the dB (A) data from the measurement results, the measurement data analysis is carried out to get the WECPNL value. The measurement results calculated to obtain the WECPNL value can be seen in Table 8.

The simulation results of noise distribution contours using ArcGIS software, which are classified based on noise levels using the WECPNL noise index, can be seen in Table 8.

To find out the contour simulation results in Figure 3, the noise level zone is divided into three zones with a buffering method of 1 km from the airport area point, as in Table 9.

Table 8. Recapitulation of WECPNL Index Values

No	Sample	dB(A)	N	WECPNL	Regional Level
1	Runway	60.59	81	52.68	III
	Taxiway	71.57	81	64.48	
	Apron	74.38	81	66.47	
	Number		**81**	**183.63**	
2	Terminal	85.60	80	76.80	II
3	Residential Area	75.31	74	67.83	I

Source: 2023 Analysis

Table 9. Noise Level Based on WECPNL Index

Noise Area	WECPNL Index	WECPNL Value	Noise Level
Residential Area (BTN)	70<WECPNL<75	67.83	I
Terminal Area	75<WECPNL<80	76.80	II
Airside area (Runway, Apron, Taxiway)	WECPNL>80	183.63	III

Source: 2023 Analysis

Table 10. Noise Levels Based on Index

Buffering (km)	Buffering Area (km^2)
1	1.54
2	10.18
3	21.52

Source: 2023 Analysis

From the table above, noise levels can be zoned into high (1 km), medium (2 km) and low (3 km). In each buffering zone, residential areas and public facilities are affected by the noise effects of airport activities (Raimi & Adindu, 2019).

Based on Figure 3, the simulation results of the noise distribution contours have been classified into noise areas. According to Government No. 40 of 2012, the distribution of airport noise can be determined. Level I noise areas with a WECPNL index of 67.83 dB are green, level II noise areas with a WECPNL index of 76.80 dB are yellow, and level III noise areas with a WECPNL index of 183.63 dB are red.

According to Government Regulation No. 40 of 2012, level I noise areas can be used for various activities and buildings except for hospital and school buildings (Brown & Kamp, 2017).

Based on the simulation results of the noise contour map at Haluoleo Kendari Airport, there are no hospital or school buildings in this level I noise area, only residential buildings covering an area of 2.14 km2 and one mosque prayer facility. A map of the level I noise area can be seen in Figure 4.

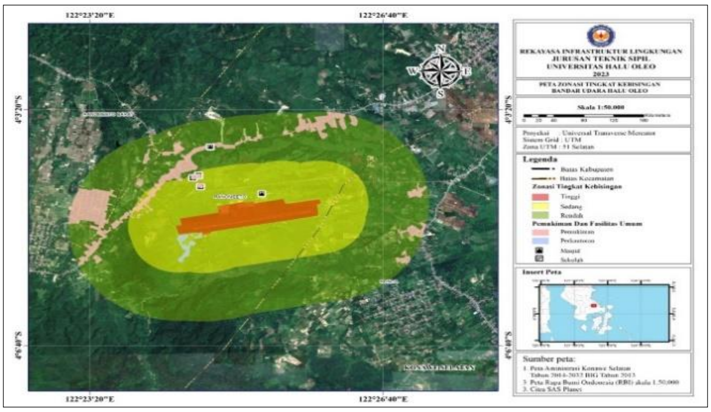

Figure 3. Simulation of Noise Distribution Contours at Haluoleo Airport

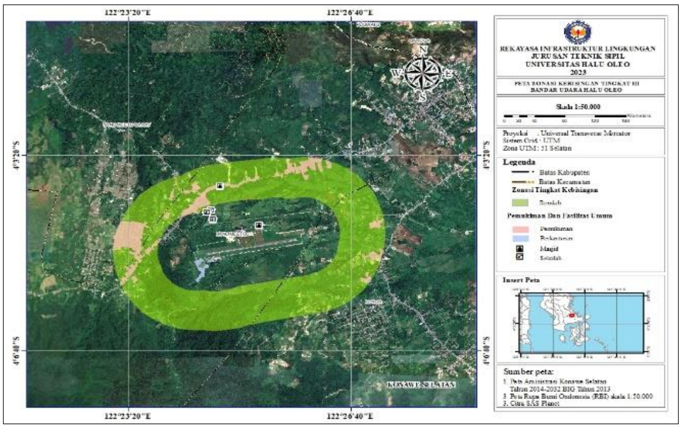

Figure 4. Level I Noise Distribution Contour Simulation at Haluoleo Airport

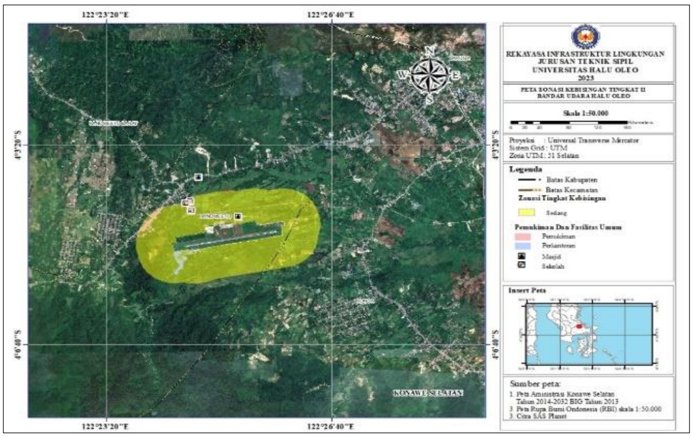

Figure 5. Level II Noise Distribution Contour Simulation at Haluoleo Airport

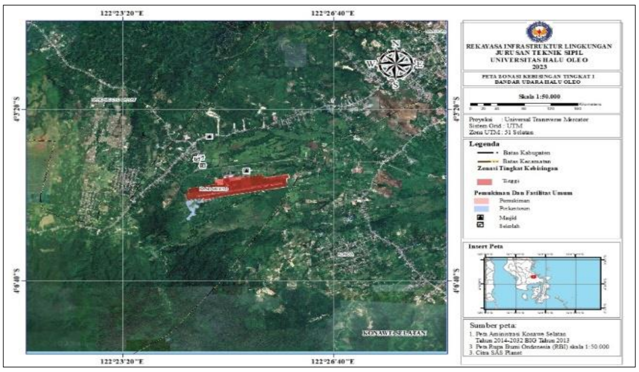

Figure 6. Level III Noise Distribution Contour Simulation at Haluoleo Airport

Level II noise areas can be used for various activities and buildings except for hospitals, schools and residential buildings. However, based on the results of the noise contour map simulation, there are settlements in the level II noise area, settlements that are included in the level II noise area covering an area of 0.18 km2, one office facility building, namely the Haluoleo Air Force Area (AU), three school buildings that are included in the level area. II are SD Negeri 5 Ranomeeto, SMP Negeri 8 Konsel and SMA Angkasa, and one building for worship facilities, the AT-Thoiroot Ranomeeto mosque. The level II noise area map in Figure 5 shows the area of settlements included in the noise area.

Level III noise areas can be used to build airport facilities with sound insulation. They can be used as green belts or environmental and agricultural control facilities that do not attract birds. Based on the noise contour map simulation results, no schools, hospitals, or residential areas were included in the level III noise area. The regions in level III can be seen in Figure 6.

4. CONCLUSION

This study addresses the critical issue of noise pollution around Haluoleo Kendari Airport due to increased aircraft landing and take-off activities. Noise levels were measured at three distinct locations, and the findings revealed significant exceedances of noise quality standards as per Minister of Environment Decree No. Kep.48/MENLH/11/1996. The runway, taxiway, and apron area recorded a WECPNL value of 183.63 dB(A), far surpassing the permissible threshold of 80 dB(A). Similarly, the airport terminal area measured a WECPNL of 76.80 dB(A), exceeding the allowed limit of 60 dB(A). In the BTN Khalifa Resident housing area, the noise level was 67.83 dB(A), exceeding the residential standard of 55 dB(A).

The noise distribution analysis, based on Government Regulation No. 40 of 2012, categorized the areas into three zones. Zone III (high noise level) is restricted to airport facilities and complies with government regulations. Zone II (moderate noise level) includes residential buildings, schools, and a prayer facility, violating government regulations due to inappropriate land use. Zone I (low noise level) includes residential buildings and a mosque, which align with regulatory standards.

These findings underscore the urgent need for effective noise management and land-use planning around the airport. Measures such as establishing noise buffer zones, implementing soundproofing technologies, and adhering to zoning regulations are essential. These steps can mitigate noise impacts, protect the health and well-being of affected communities, and ensure sustainable airport operations while maintaining compliance with environmental standards. This study highlights the importance of integrating noise pollution management into urban planning strategies for areas surrounding airports.

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