# Mitigating the Impact of Aircraft Noise on the Functional Pattern of Open Spaces around Adi Soemarmo Airport, Boyolali

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**Abstract.** The automatic operational noise of Commercial Aircraft (CA) and Fighter Aircraft (FA) engines causes latent disturbances to the surrounding physical and non-physical. Based on the measurement results, especially when landing, the noise pressure of Commercial Aircraft feels loud and gets louder when touching the runway starting from the take-down marking, aiming point until approaching the stop. Meanwhile, for Fighter Aircraft, the flight duration is continuous and without landing on the runway for a certain period of time. The movement formation of Fighter Aircraft has generated very loud noise, so that it has an impact on causing vibrations in the surrounding environment as well as the nerves of the head and heart. The research was conducted using a qualitative (descriptive) method to read quantitative data. The quantitative data is in the form of a dependent variable, namely open space area, distance between open spaces, time and settlements.Meanwhile, the independent variable is a table of noise from commercial aircraft and fighter aircraft during March and April 2025. The research results explain the open space pattern based on the zoning of aircraft noise areas, which require residential-scale noise reduction facilities. The radius of the open space area requires the closure of water sources around the airport perimeter fence with iron bars. Meanwhile, the height and type of plants require more low-lying plants to reduce the frequency and waves of aircraft noise (Doppler effect).

**Keyword**: mitigation, noise, aircraft, open space, plants

## 1. Introduction

The noise of Commercial Aviation (CA) and especially Fighter Aircraft (FA) can have an impact on physical and non-physical disturbances for humans, animals and plants. In the observation process, noise is a product of the automatic operation of aircraft engines, which does not consider the environmental impact. Based on field measurements, starting from the minimum to maximum noise pressure, in units of Decibel Ampere (dBA), it is identical to the character of air and water, which always fills the entire space with different pressures and volumes. The noise of Commercial Aviation (CA) increases when approaching the runway (still in the air) and when touching the runway starting from take-down marking, aiming point until approaching stop. Meanwhile, for Fighter Aircraft (FA), the flight duration is continuous and without landing on the runway for a

certain period. In continuous duration, large noise and certain formations, the aircraft has caused vibrations that disturb the heart and nerves of the head. Therefore, it is known that aircraft noise predictions can reproduce the actual impact of air traffic operations, due to the complexity of complex airspace and variations in meteorological conditions.[1]This is explained through the following image:

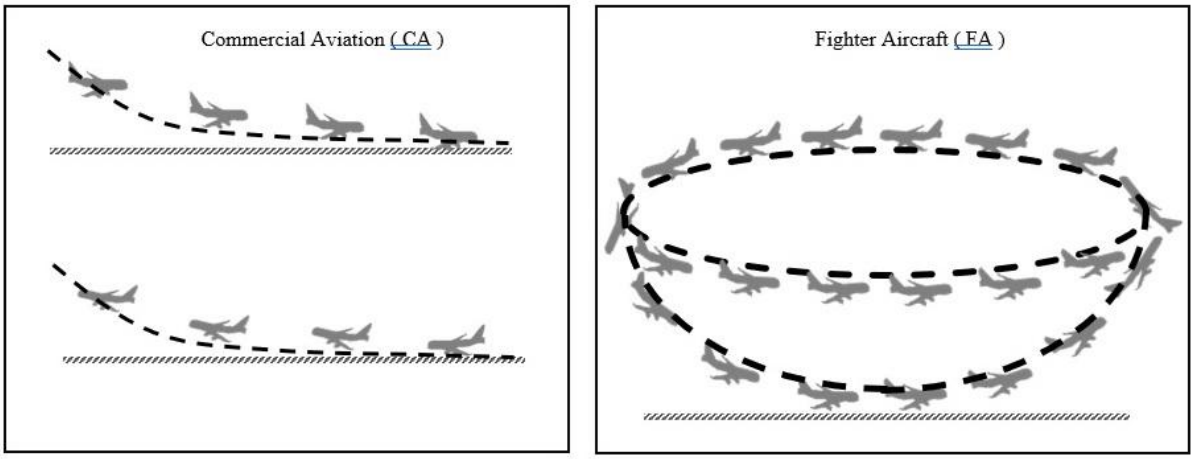



Figure 1. The pattern of aircraft movement on the runway of Adi Soemarmo Airport, Boyolali

Although there are sounds of passing vehicles and megaphone around the landing area, they only slightly reduce the noise pressure and are temporary. The landing process produces greater noise pressure than during takeoff. The eastern part of the airport receives the greatest noise compared to the western and southern parts of the airport. Meanwhile, the presence of open spaces around the airport, especially the eastern part, can hardly reduce the noise. Even the noise when inside the house feels louder when compared to when outside the house. However, residents have become accustomed to it, because they live and work around the area. In relation to settlements around areas affected by aircraft noise, the classification scheme for new and existing building requirements is 5 dB, for both air insulation and impact sound insulation.[2].This area can be observed through the following image:

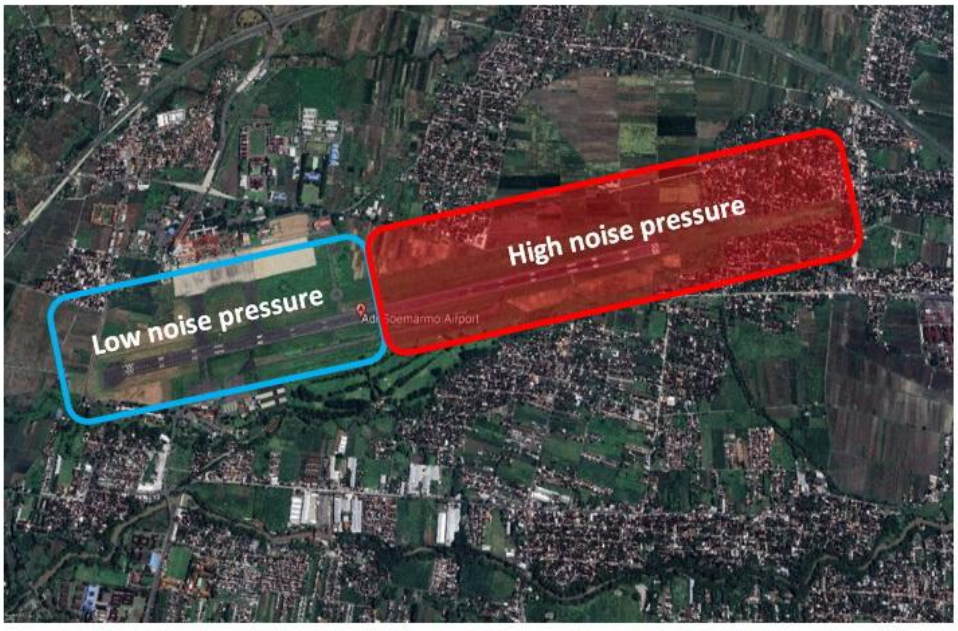



Figure 2. Aircraft Noise Pressure Area around the Runway of Adi Soemarmo Airport, Boyolali

For a smooth landing, the noise intervals are regular and sequential. For a rough landing, however, the noise intervals are irregular, and even after reaching the runway, the noise is very loud (similar to an explosion) and reverberates in all directions. It is further explained that RT-based aircraft noise prediction phenomenologically accounts for meteorological variations that alter the impact of air traffic noise, through atmospheric effects (e.g., refraction, convection, and absorption). Local weather conditions thus provide results to restore the complex effects of the atmosphere and open space on the propagation and impact of aircraft noise, stabilizing computational complexity and cost.[3] However, for immigrants as well as animals and plants, this noise poses a particular problem. This impact is measured through. Average noise levels, aircraft noise affecting the room, window reinforcement /airtightness and the application of double walls and the response level to loudness and very high. Then the noise affects telephone calls, conversations, listening to TV and radio, sleep rhythms, concentration, and rest time.[4].Based on this problem, researchers are interested in exploring the function and existence of open spaces around airports regarding aircraft noise.

## 2. Method

The research uses a qualitative (descriptive) method to read quantitative data. The quantitative data is in the form of a dependent variable, namely open space area, time and settlement. Meanwhile, the Independent Variable is a table of noise from Commercial Aircraft ( CA ) and Fighter Aircraft (FA) during March and April 2025. From this data, it will be analyzed descriptively.

## 3. Results and Discussion

### *3.1. Zonification of Aircraft Noise Areas*

Noise Commercial Aviation (CA) and especially Fighter Aircraft (FA) are heard throughout the airport area within a certain radius, with varying noise levels. The highest noise levels, detected by flight radar and sound level meters, are in the eastern area and slightly to the south. The following is a map showing the location.


Figure 3. Largest Noise Areas in Residential Areas and Open Spaces East and South of the Runway
*Source: Google Earth, 2025 Redraw by Dyah*

The red line area is the highest noise path from Commercial Aviation (CA ) and especially Fighter Aircraft (FA), especially during landing. While the yellow line area is the area affected by the noise. The area consists of open space, residential groups and public facilities (mosques, cemeteries, gutters) located around the runway boundary line. The open space is limited by wire fencing, the placement of runway edge lights, approach lighting systems and threshold lights and is sterilized from human crossings. Meanwhile, the noise from Commercial Aviation (CA) and Fighter Aircraft (FA) crossings is based on the results of field measurements in the morning, afternoon, and evening, in the month of March and April 2025, the following data was obtained:

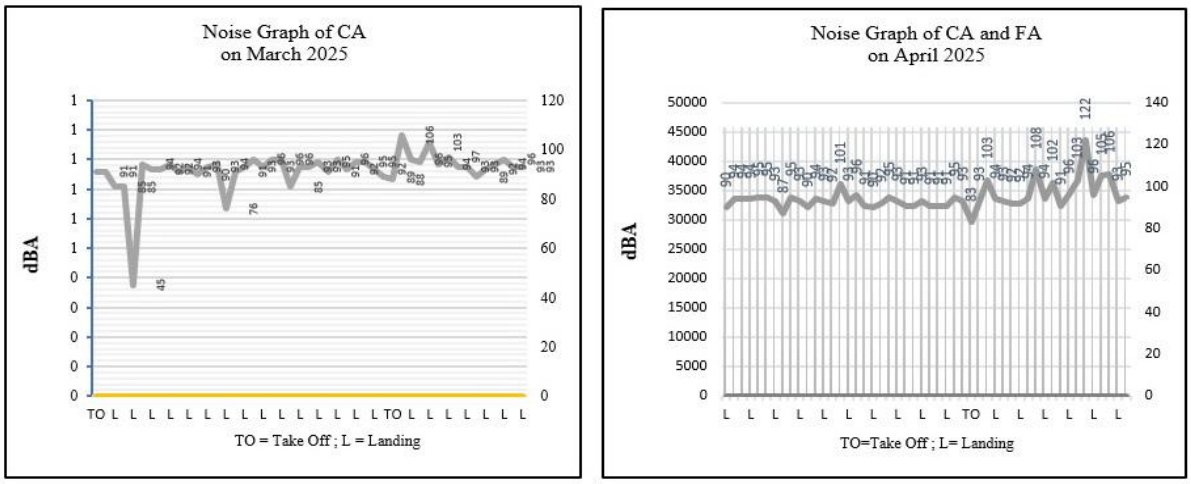



Figure 4. Graph of Commercial Aviation ( CA ) and Fighter Aircraft ( FA ) noise on April 2025

In March 2025, only Commercial Aviation (CA) crossings were recorded, while in April 2025, Commercial Aviation (CA) and Fighter Aircraft (FA) crossings were recorded, alternating in space and time. The short-duration Fighter Aircraft (PT) noise, the highest noise detected was around 122 dBA while the lowest was around 91 dBA. Based on these data, the analysis of the relationship and influence of noise in the affected areas and objects, was obtained through the following assessment:

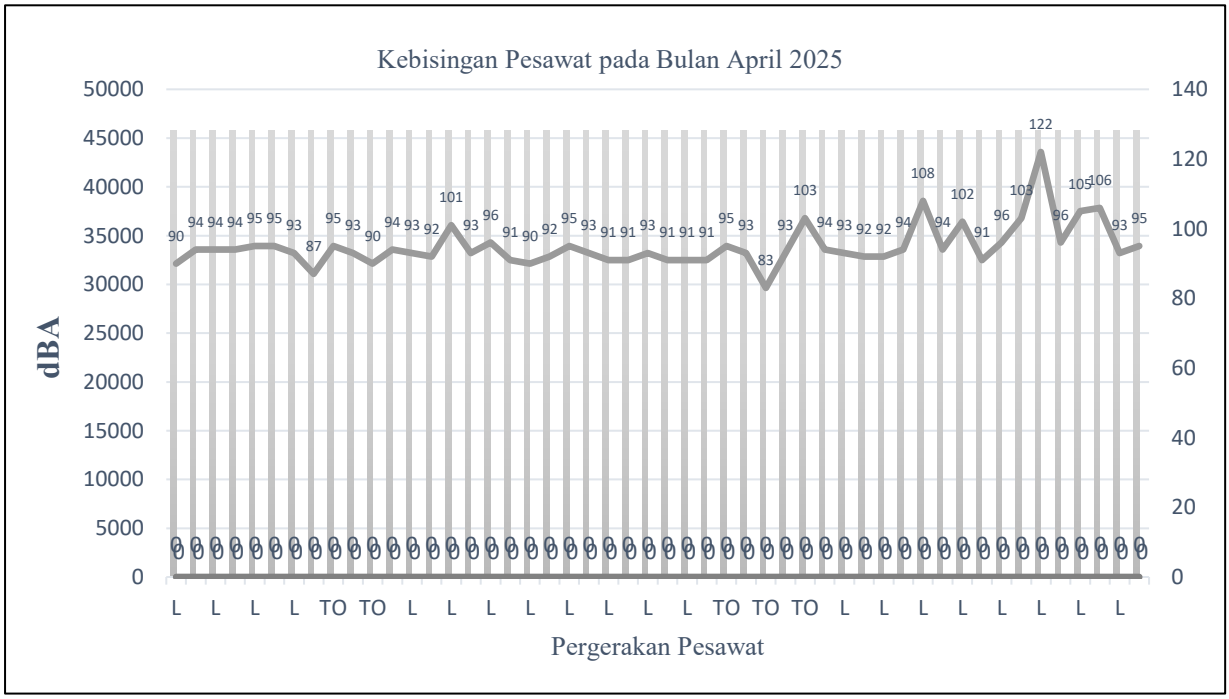
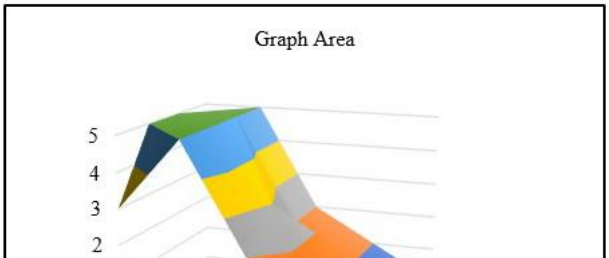



Table 1. Effect of Aircraft Noise on Area Zoning

| Direction | Settlement | | Open Space | Facility General | Human Activities |
|---|---|---|---|---|---|
| North | 3 | | 5 | 5 | 4 |
| East | 5 | | 5 | 5 | 5 |
| South | 2 | | 3 | 2 | 2 |
| West | 1 | | 1 | 1 | 1 |
| Noise Value | 1 | 2 | 3 | 4 | 5 |
| | Very weak | Weak | Currently | Strong | Very strong |

*Source: Commercial Aircraft and Fighter Aircraft Noise Graph, 2025*



Building elements are apparently able to reduce noise, especially sloping roofs can deflect aircraft noise, thus reducing noise levels in courtyards and near facades away from the flight path. It also depends on the direction of the noise, meteorology, and visibility (e.g., >10 dB(A) for departures), as the built environment significantly influences the propagation of aircraft noise. However, it does not support overhanging buildings or architectural design strategies to reduce aircraft noise.[5].

Besides that,thin fiberglass material can be applied to sandwich building elements, to form panels to reduce noise and structural noise transmission, noise barriers, dampen machine vibrations, and reduce structural vibrations of buildings.[6]So Geometric building envelope design elements, textured building surfaces, and increased sound-absorbing materials, multisensory and integrated design strategies can reduce outdoor noise levels. Additionally, glass windows can reduce noise from the outside, but they carry risks. For composite materials, increasing fiber volume fraction, decreasing porosity, and thus reducing sound transmission.[7]. AlsoThe passive open window concept is the best option to consider for anticipating and managing aircraft noise, which has negatively impacted the environment since the beginning of urban planning. This minimizes noise complaints, leading to improved quality of life.[8].Based on various considerations (in Germany), the dataGeographical apartment and noise contour maps at German airports influenced price increases of around 2.4% after the pandemic began. Lack of disamenity (high noise exposure) led to a rapid reaction in the housing market.[9].

Regarding health stability, it turns out thatTraffic noise affects the health of adults ( Bulgaria ), based on the WHO curve for calculating the nuisance load from road traffic and aircraft noise.[10]. There was a reductionflights and switching to other modes of transport have practical implications for the local economy and employment, absolute emission reductions and the transition to safe and environmentally friendly employment.[11]. In addition, it is necessaryNoise sensitivity, age, and dissatisfaction with the living environment affect sleep quality. Therefore, the living environment should be adjusted to reduce the impact of noise on residents around the airport.[12]. Then kNoise in residential areas cannot be ignored.[13].

### *3.2. Radius of Open Space Area*

The hustle and bustle of music, vehicles, firecrackers, and speakers, measured at around 72 dBA, apparently does not reduce the noise pressure of commercial aircraft or fighter jets. The 93 dBA figure before landing feels softer than when touching the runway at around 60 dBA. Aircraft noise during pre-start on the runway is around 60-75 dBA. Land contours, the accuracy of vegetation, and the position of houses affect noise. The higher these 3 factors, the higher the noise. Wind blows when the plane lands. Noise is reduced but the exhaust airflow becomes large. The following is explained through the observation coverage area notification:

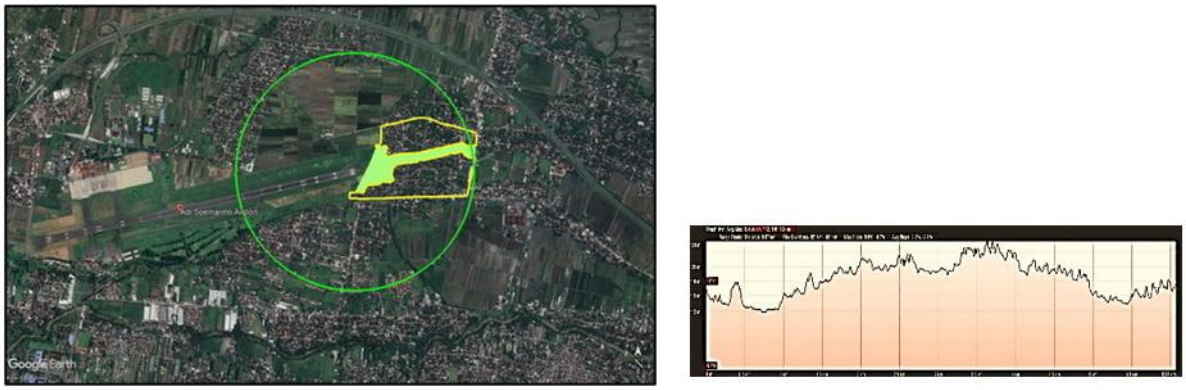



Figure 6. Radius of Noise Space of Commercial Aviation ( CA ) and Fighter Aircraft ( FA )
*Source: Google Earth, 2025 Redraw by Dyah*

The area bounded by a green polygon has an area of 0.11 km2, a circumference of 2.66 km, a latitude of -7.513211°, a longitude of 110.772038° and a range of 540m, a tilt of 10.000000°. The open space is positioned between residential areas and public facilities to the North-East (1) and South-East (2). While the green polygon circle explains the noise observation area. Based on observations and measurements of noise sources and accessible open spaces, it is known that the noise area has a radius of 948.5 m, an area of 2.83 km2 and a circumference of 5,959.29 m. Based on the Google Earth map, the East and South of the airport are contoured areas. However, the contour does not have an impact on noise reduction.

Commercial Aviation (CA) noise is around 93 dBA before landing and reaches around 90-60 dBA when it reaches the runway. Meanwhile, Fighter Aircraft (FA) F-16 during take off produce noise of around 60-75 dBA, before landing produce noise of around 62-77 dBA, then after reaching the runway the noise increases to around 71-73 dBA. The data is shown in the following image:

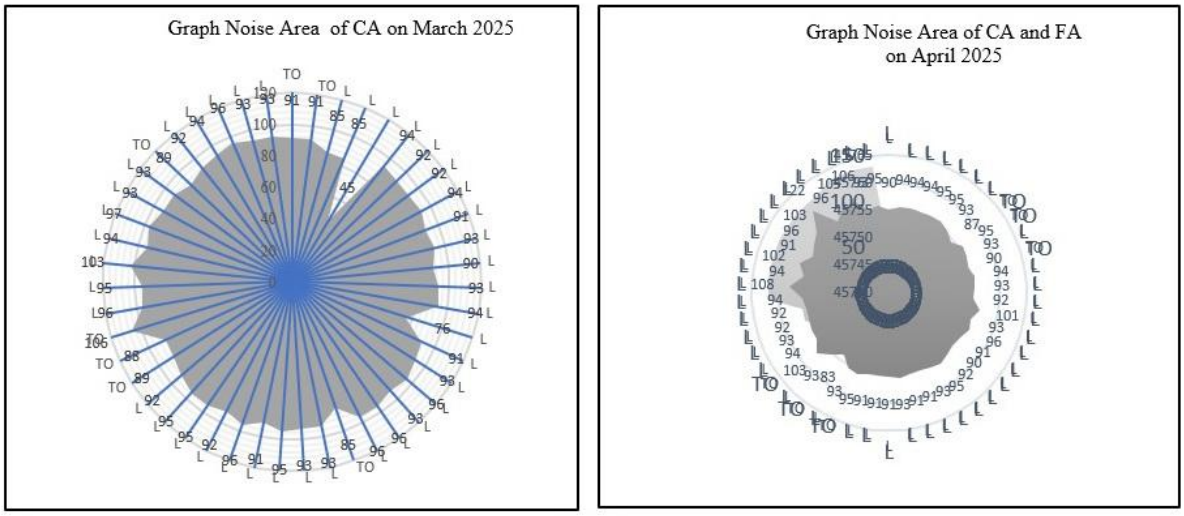



Figure 7. Aircraft Noise Area Radius Graph

Table 2. Effect of Open Space Area Radius on Aircraft Noise Speed

| Direction | Aircraft Impact | | Take off | Landing | Time |
|---|---|---|---|---|---|
| North | 3 | | 3 | 3 | 3 |
| East | 5 | | 5 | 5 | 5 |
| South | 1 | | 1 | 1 | 1 |
| West | 2 | | 2 | 2 | 2 |
| Noise Value | 1 | 2 | 3 | 4 | 5 |
| | Very weak | Weak | Currently | Strong | Very strong |

*Source: Commercial Aviation (CA) and Fighter Aircraft (FA) Noise Graph, 2025*

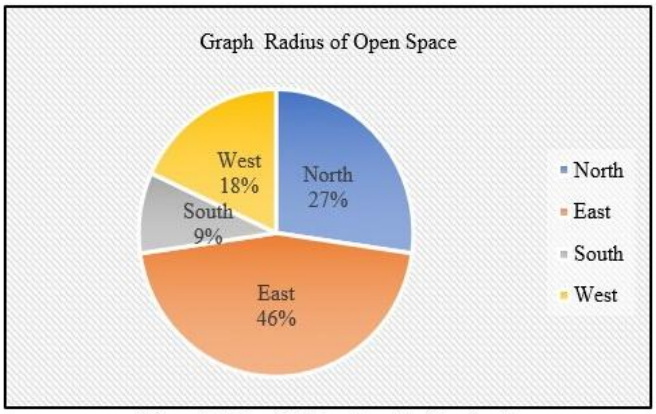



Figure 8. Aircraft Noise Area Radius Graph

It is also known that sound waves propagate in a medium, so the speed of the observer and the source of the wave are relative to the medium. The total Doppler effect is produced by the motion of the source, the motion of the observer, or the motion of the medium. Each effect must be analyzed separately. Waves without a medium (light or gravity) in general relativity, only have a relative difference[14].The Delphi survey produced a collective understanding of open space that can predict open space physically and related subjective elements based on perception.[15]. Then based on other research, it is explained thatincreasing informal land use (Cape Town) describes evidence of the impact of policy interventions (settlement upgrading and population relocation initiatives), demonstrating the potential for methods that are easily accessible and implementable without resources or technical expertise.[16]. Then existenceThe topography of open spaces around airports and the rural nature of the transportation network significantly influence the choice of transportation mode. Furthermore, financial incentives also need to be considered to balance changes in travel costs and comfort.[17]. In relation to the interaction

between environmental elements, it turns out thatassessment of the interaction between the built environment and the ecosystem, requires a holistic approach utilizing correlation analysis and non-destructive testing, for resource efficiency for the sustainability of the built environment in general[18]. Then regarding the impact of transportation facilities, it is processed throughquantitative analysis yields more diverse traffic patterns than previous classifications.[19]. SThe noise point system functions to monitor and limit the impact of noise, also to ensure changes in the sustainable air transportation system.[20].

### *3.3. Height and Type of Plants*

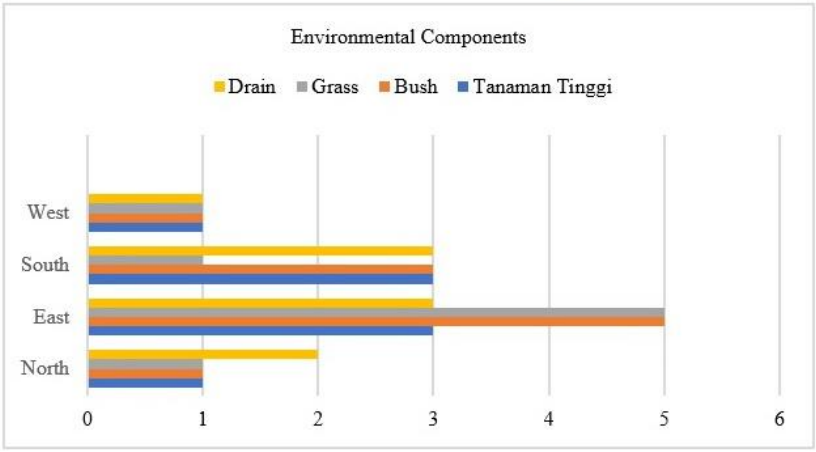
The open space around Adi Soemarmo Airport is largely comprised of low-growing plants and a small portion of taller plants. Residential areas, activity areas, and public facilities are located on the border of the planted zone. Furthermore, animals and insects such as lizards, frogs, snakes, butterflies, birds, and so on are also present. The following are the locations where open space is restricted:

Figure 9. Fence area, open space and observed plants

Table 3. Effect of Plant Existence on Noise Area Zonification

| Direction | Tall Plants | | Bush | Grass | Drain |
|---|---|---|---|---|---|
| North | 1 | | 1 | 1 | 2 |
| East | 3 | | 5 | 5 | 3 |
| South | 3 | | 3 | 1 | 3 |
| West | 1 | | 1 | 1 | 2 |
| | | | | | |
| Noise Value | 1 | 2 | 3 | 4 | 5 |
| | Very weak | Weak | Currently | Strong | Very strong |

*Source: Commercial Aviation (CA) and Fighter Aircraft (FA) Noise Graph, 2025*



The wind blew hard as the plane landed smoothly. Perhaps the noise was reduced and normalized by the strong gusts of wind.

Through mnoise and soundscape mapping methods, showing that aircraft noise will reduce the quality of nature experience and have a negative impact on wildlife habitats (mountain national parks in Korea).[21]. On the other hand, it turns outThe age and size of the aircraft reduce environmental costs by 0.32%. , fuel consumption savings; resulting in low pollution, and a complementary relationship between pollution and environmental costs of noise disturbance.[22]. Then regarding the response,Noise sensitivity, the presence and evaluation of household noise isolation, are short-term assessments, influenced by the time, activity and location of the respondent. Meanwhile, attitudinal and social factors play a small role in assessing short-term disturbance.[23]**.**

TemporaryIn residential areas, the existence of green open spaces and vegetation is very important, because it reduces noise exposure, creates visual and acoustic quality in densely populated areas and reduces road and train traffic noise.[24]. This is supported bythe main components of the soundscape, which can be traced empirically through their relative prevalence across seasons. It is known that anthropogenic noise is a major component of the soundscape of protected habitats, which has a significant impact on the behavior and ecology of local animals.[25]Whereasnegative impacts of anthropophony on freshwater soundscapes, observed spectral and temporal overlap with biophony, higher ambient sound levels of anthropophony relative to biophony, and observed significant decreases in the occurrence, number, percentage of time, and diversity of biophony at higher ambient sound levels.[26]**.**Vegetation on the building envelope has the potential to reduce noise and soundscape performance.[27].

## 4. Conclusion

The research results explain the open space pattern based on the zoning of aircraft noise areas, which require residential-scale noise reduction facilities. The radius of the open space area requires the closure of water sources around the airport perimeter fence with iron bars. Meanwhile, the height and type of plants require more low-lying plants to reduce the frequency and waves of aircraft noise (Doppler effect).

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