

**Bird Strike Risk Assessment to Support Flight Safety: A Case Study at Kalimantan Airport
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ABSTRACT

Bird strikes pose a serious threat to aviation safety, especially at airports surrounded by natural habitats that attract birds. This study aims to identify bird species with the highest risk to aviation safety at Kalimantan Airport, Berau, and provide mitigation recommendations based on risk analysis results. The method used is a descriptive quantitative approach with risk assessment techniques using the Sowden and MOORA methods. The results of the study show that the species *Egretta garzetta* (little egret) has the highest score in both assessment methods, thus categorized as the species with the highest bird strike risk. This is due to the birds' gregarious behavior, low-flying habits, and the airport's surrounding habitat, which provides natural food sources and shelter. The conclusions of this study support the hypothesis that there are bird species with high bird strike risk at Kalimantan Airport. Comprehensive habitat management and the use of early detection technology are necessary as strategic measures to reduce the potential for bird strike incidents.

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INTRODUCTION

Aviation safety is a key aspect of the air transport industry, and threats from wildlife, particularly birds (bird strikes), are one of the real risks that continue to increase [1]. A bird strike is defined as an incident where a bird or other wildlife collides with an aircraft during operational processes, particularly during takeoff, landing, and the initial climb phase. According to the ICAO Airport Services Manual Part 3, most bird strike incidents occur during takeoff and landing, as the aircraft is at a low altitude and within close proximity to the airport environment [2]. Bird strike incidents cause significant losses to the aviation industry. Incidents caused by bird strikes can result in 3.6% of serious damage to aircraft and financial losses of 1.2 billion US dollars annually [3].

Globally, the Bird Strike Committee USA/Canada records over 14,000 bird strike incidents annually in North America [4]. In Indonesia, bird strike incidents have been reported to occur quite frequently, such as at Soekarno-Hatta Airport, Sultan Hasanuddin Makassar Airport, Juanda Surabaya Airport, and other airports, with the number of bird strike incidents increasing each year [5]. Bird strike incidents do not only occur at the major airports mentioned earlier; Kalimantan Berau Airport has also experienced similar incidents. This highlights the need for more comprehensive and data-driven mitigation measures.



Figure 1. Discovery of Dead Birds in the Airside Area of Kalimantan Airport

Kalimantan Berau Airport is one of the Class I Airport Management Units located in Berau Regency, East Kalimantan Province, characterized by an open environment with low vegetation, and situated near conservation areas and water sources, which naturally attract birds [6]. The tall grass areas and water ponds around the Kalimantan Airport fence are frequently used by birds. This condition increases the potential for bird strike incidents and necessitates a risk assessment related to wildlife hazards.

Several studies have been conducted to analyze bird strike risks at airports. Various studies in different countries emphasize the importance of systematic bird strike risk management [7]. In Indonesia, for example, the study by Nursani & Arifianto [8], analyzed wildlife hazard risks using the Sowden method and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) at XYZ Airport. This study serves as a benchmark for researching wildlife hazards, specifically bird strikes, at Kalimantan Airport. However, most other studies related to bird strikes in Indonesia remain descriptive and have not yet detailed the connection between risk assessment results and local characteristics such as dominant bird species, migration patterns, and airport environmental management.

Therefore, this study aims to assess the level of bird strike risk at Kalimantan Berau Airport using a qualitative and quantitative approach. In addition, environmental factors that increase the potential for wildlife disturbances, especially birds, will be identified in order to develop strategic recommendations to reduce the risk of bird strikes in the airport area.

This study aims to assess the level of bird strike risk based on bird species found around the operational area of Kalimantan Airport, Berau. Given the airport's location, which is surrounded by natural habitats such as lakes, wetlands, and agricultural areas, as well as the increasing incidence of bird strikes at various domestic airports, a structured study is needed to determine whether there are certain species that can be categorized as high risk. Based on these considerations, this study formulates the following hypotheses:

- Alternative Hypothesis (H₁):
There are bird species that pose a high risk of bird strikes to flight safety at Kalimantan Airport.
- Null Hypothesis (H₀):
There are no bird species that pose a high risk of bird strikes to flight safety at Kalimantan Airport.

METHODS

This study uses quantitative methods supported by qualitative data in the form of observations and literature studies [9]. This approach is used to gain a comprehensive understanding of bird strike issues at Kalimantan Berau Airport. Qualitative data was collected using field observation and literature study techniques to identify the types of birds that appear around the airport and the environmental factors that support bird activity around the airport. Quantitative data was collected and analyzed using the Sowden and MOORA methods [8].

The Sowden method focuses on two main aspects: the social characteristics of the bird population and their body weight. This approach is used to assess the potential for collisions between birds or wild animals and aircraft, which can cause damage to assets or facilities. Bird body weight is an important indicator because the larger the size, the greater the potential damage caused during a collision. Meanwhile, bird social behavior is also considered because the number of individuals in a group influences the severity of an incident if a collision occurs. Therefore, the risk level can be classified into several categories as follows: In the methods section, the section that details and systematically explains the steps taken in conducting the research. In this chapter, the author must provide enough detailed information so that the reader can clearly understand how the research was conducted and how the data was collected. Methods can be described through the steps taken and can be assisted by using figures or tables.

Table 1. The Sowden Method Classification Table[8]

<i>Severity of Risk</i>	<i>Species Characteristics</i>	<i>Interpretations</i>
Level 1	<i>Very large (>1.8 kg), flocking</i>	
Level 2	<i>Very large (>1.8 kg), solitary</i> <i>Large (1-1.8kg), flocking</i>	
Level 3	<i>Large (1-1.8 kg), solitary</i> <i>Medium (300-1000 g), flocking</i>	<i>May cause significant harm</i>
Level 4	<i>Medium (300-1000g), solitary</i> <i>Small (50 – 300 g), flocking</i>	
Level 5	<i>Small (50-300 g), solitary</i>	<i>Generally, does not cause significant accidents, although some minor damage may occur</i>

Meanwhile, the MOORA method is used to assess certain parameters of bird characteristics, such as flight ability, location of activity in the airport area, and the number of individuals of each species observed. The formula for determining the risk score (TB) of each type of bird whose characteristics have been identified is as follows[8]:

$$TB = L * (BB + P + T) \tag{1}$$

The TB score for each bird species is interpreted using the following table:

Table 2. MOORA Interpretation [8]

Danger Level (TB)	Interpretation
>60	<i>Very High</i>
45 – 60	<i>High</i>
30 – 45	<i>Average</i>
15 – 30	<i>Low</i>
<15	<i>Very Low</i>

The characteristics of birds used as benchmarks for calculating the MOORA method are as follows:

1. Determining Bird Flight Height (T)

The flight capabilities and heights of each type of animal are classified based on their height from the ground into the following categories:

- Types that cannot fly are given a score of 1.
- Types that can only fly at very low altitudes (below 5 meters) are given a score of 2.
- If they can fly up to an altitude of 30 meters, the score is 3.
- If they can reach an altitude of up to 100 meters, the score is 4.
- Types that can fly more than 100 meters will receive a score of 5.

2. Determination of Bird Activity Location (L)

The assessment is based on the location of birds in relation to critical aircraft movement areas (such as runways, taxiways, and aprons), as well as the tendency of each bird species to approach or cross these areas, with the following categories:

- If located outside the critical area, a score of 1 is given
- If the location is far enough away and the possibility of crossing the critical area is low, a score of 2 is given
- If the position is still relatively far away but there is a potential to cross the critical area, a score of 3 is given
- If located within or around the critical area and has the potential to cross it, a score of 4 is given
- If located directly on the aircraft movement path, a score of 5 is given

In this observation activity, the observation points were determined as shown in the figure below. The observation points were selected because the area has been used as a bird monitoring location by Kalimantan Berau Airport.

Points A and D are located in the landside area of Kalimantan Airport, while points B and C are located in the airside area and in a pond adjacent to taxiway C. Points A and D each received a score of 3 because they are outside the critical area but still have the potential to be crossed by birds. Meanwhile, points B and C were given a score of 5 because they are located in areas with a high potential for bird strikes.

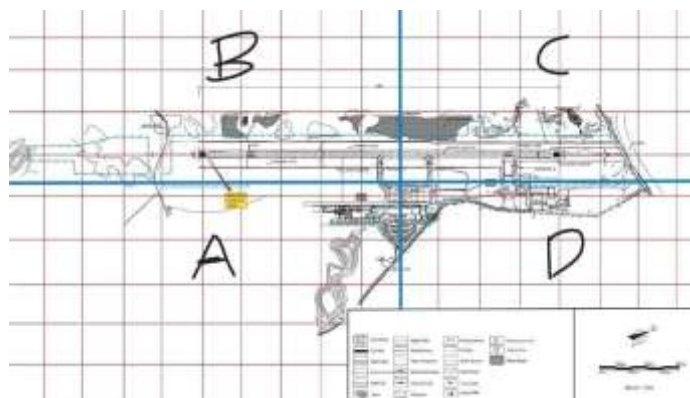


Figure 2. Division of Areas to Determine the MOORA Method

3. Determining Population Size (P)

Based on the results of the preliminary population estimate, the value of P for each bird species is determined from the total number of individuals found at the research site. The assessment categories are as follows:

- If the number is less than 50 individuals, it is given a score of 1
- If the number between 50 and 99 individuals receives a score of 2
- If the number between 100 and 249 individuals is given a score of 3
- If the number between 250 and 499 individuals is given a score of 4
- If the population exceeds 500 individuals, the score is 5

Field observations were conducted during the on-the-job training period from October 2024 to February 2025 at four predetermined points (A and D in the landside area, B and C in the airside area near taxiway C). Observations were carried out twice daily during peak bird activity periods (06:00–09:00 and 15:00–18:00 local time). Each session involved direct visual counting, assisted by binoculars and photographic documentation. The observation cycle was conducted repeatedly throughout the training period, with a total of 14 observation sessions to ensure data consistency and representativeness of bird species activity and movement around Kalimantan Airport.

Research variables are divided into independent and dependent variables. Independent variables in this study refer to bird characteristics and environmental factors, while dependent variables refer to the level of bird strike risk.

RESULT AND DISCUSSION

Environmental Conditions at Kalimantan Berau Airport

The condition of the Kalimantan Berau Airport area shows that the terminal and airside areas are surrounded by lakes, plantations, and dense forests. The problems that often occur can be summarized as follows:

Table 3. Environmental Conditions at Kalimantan Berau Airport

No.	Current conditions	Desirable conditions	Dasar Hukum
1.	The abundance of habitats or places that can be used as dwellings or foraging grounds for birds in the area surrounding the airport	Minimize places that are likely to become habitats and feeding grounds for birds.	SKEP / 42 / II / 2010 (Regarding Guidelines and Procedures for Civil Aviation Safety Regulations Part 139 – 03 Management of Wild Animal Hazards at Airports and Surrounding Areas)
2.	The methods and equipment used to control the presence of birds in the airside area of Kalimantan	Kalimaru Berau Airport is working to improve effectiveness by adding and optimizing	SKEP / 42 / II / 2010 (Regarding Guidelines and Procedures for Civil Aviation

	Berau Airport are considered to be less than optimal in their application.	equipment to repel birds.	Safety Regulations Part 139 – 03 Management of Wild Animal Hazards at Airports and Surrounding Areas)
3.	The lack of a special team at the airport means that risk management for bird strikes cannot be carried out in a systematic and coordinated manner.	It is recommended that the management of Kalimantan Berau Airport immediately develop a plan to form a special team tasked with handling potential bird strike incidents.	SKEP / 42 / II / 2010 (Regarding Guidelines and Procedures for Civil Aviation Safety Regulations Part 139 – 03 Management of Wild Animal Hazards at Airports and Surrounding Areas)

In addition to the aforementioned issues, the area surrounding the airport still has a number of natural habitats that support bird populations. This area provides an ideal source of food and shelter for birds, such as tall grass that serves as a habitat for insects, which in turn become the primary food source for birds. Additionally, the water bodies around the airport area attract birds to come, play, and drink. These conditions indirectly enhance the airport environment's appeal to birds, thereby increasing the potential risk of birds entering the operational flight area.



Figure 3. The Lake Environment and Long Grass Surrounding the Airport

Discussion of Risk Assessment Results

Based on observations of bird species active around Kalimantan Berau Airport, a combined risk assessment analysis using the Sowden and MOORA methods was conducted. The results are presented in the following table:

Table 4. Risk Assessment Results Using Sowden and MOORA Methods

No.	Bird Species		Parameters				Calculation Results		
	Scientific Name	Local Name	L	BB	P	T	Score	TB	Sowden Level
1.	<i>Spilopelia chinensis</i>	Turtledove	4	4	4	3	44	Average	5
2.	<i>Dendrocygna</i>	Whistling Duck	4	3	4	4	44	Average	5
3.	<i>Ciconia episcopus</i>	Stork	5	1	4	5	50	High	3
4.	<i>Egretta Garzetta</i>	Little Egret	5	4	3	4	55	High	4
5.	<i>Spilornis Cheela</i>	Crested Serpent Eagle	5	2	1	5	40	Average	3

The results of bird strike risk analysis at Kalimarau Airport show that the little egret (*Egretta garzetta*) is the bird species with the highest risk level. This is due to the behavioral characteristics of this bird, which tends to flock in large groups and fly low around the airport's airside area. This species has a wingspan of 88–106 cm and a body weight of approximately 350–550 grams, which is considered significant in terms of its impact on small to medium-sized aircraft.

This finding is supported by a study by Shao et al. [10], which shows that water birds with gregarious characteristics and low-flying activity have a significant correlation with the frequency of bird strikes at airports. The study utilized geographically weighted regression (GWR) modeling to show that habitats dominated by water or wet conditions contribute more to increased bird density than dry or industrial land.

Kalimarau Airport is located near a natural environment that is very conducive to bird activity. Based on field observations and documentation, it was found that around the airport there are artificial lakes, wetlands, and low vegetation areas that serve as sources of food, water, and shelter for wild birds. This environment is ideal for birds such as little egrets, moorhens, and kingfishers, which are the dominant species in this area. According to Coccon et al. [11], habitats such as lakes and wetlands statistically increase the bird attraction risk index (Attraction Risk Index) because they provide natural food sources such as small fish and aquatic insects that are difficult to control.

Given the habitat conditions around Kalimarau Airport, which provide abundant food sources (small fish, aquatic insects, amphibians) in artificial ponds and wetlands, as well as a safe environment free from predator disturbances, the frequency of little egret activity in the airport airspace is very high, especially in the morning and evening when they are actively foraging. The combination of low-flying behavior, flocking, and attraction to this habitat makes *Egretta Garzetta* the species with the highest potential risk of bird strikes at this location.

Within the framework of risk management, the results of calculations using the MOORA and Sowden methods show that the risk value for the little egret species is consistently high. In other words, from both a frequency and severity perspective, this bird is a top priority in mitigation schemes. This is in line with ICAO recommendations (Doc 9137 Part 3), which state that species with low flight intensity and group patterns require special attention in bird strike mitigation strategies.

These findings suggest the importance of a systematic approach to habitat management around airports. For example, artificial lakes or ponds that do not serve an important function in airport operations should be drained or made less attractive. According to Washburn & Seamans, habitat management is the most fundamental long-term approach because it reduces the ecological attractiveness of airports to birds without relying on expensive technology [12].

Additionally, the implementation of technologies such as avian radar systems represents a cutting-edge solution that can be further developed. This system has been successfully tested at several airports in Europe and the United States, such as Schiphol and JFK, to detect real-time bird movement and provide early warnings to air traffic controllers (ATC) and pilots before airspace conflicts occur. This technology supports rapid decision-making, such as delaying takeoff or tactically diverting runways.

Solutions and Recommendations

Based on the analysis results, there are several bird strike mitigation measures that can be implemented by the airport:

1. **Airport Habitat Management:** Modifying the landscape around the airport to make it less attractive to birds. Examples include managing grass height, disposing of food waste in closed containers, draining unnecessary puddles, and arranging vegetation that attracts birds [13].
2. **Active Bird Deterrence:** Periodic use of bird deterrents. Effective methods include sirens or predator sounds to scare birds, flashing visual devices (lasers/lights) at night, and the use of unmanned aerial vehicles (drones) as dynamic deterrents.
3. **Radar and Early Detection:** The application of avian radar technology can help monitor the movement of bird flocks in real-time before they reach the aircraft runway. This system has proven beneficial at several major airports worldwide, enabling quick decision-making by personnel to delay takeoff or implement temporary deterrence measures.
4. **Formation of a Bird Strike Task Force:** Following regulatory guidelines (PM No. 95/2021), a special unit or operational team should be formed to control wildlife hazards in the airport environment. This team is responsible for developing SOPs for wildlife management, recording incidents, and coordinating mitigation measures in an integrated manner with the airport safety management system. The availability of a specialized team will ensure more consistent monitoring and preventive actions.
5. **Public Education and Collaboration:** Enhancing awareness among airport staff and the surrounding community about the importance of bird habitat control. Awareness campaigns about maintaining airport area cleanliness and prohibiting bird feeding can help reduce bird attraction.

CONCLUSION

Based on the results of bird strike risk analysis at Kalimantan Berau Airport using the Sowden and MOORA methods, it was found that the *Egretta garzetta* (little egret) bird species poses the highest risk to flight safety. This is due to the ecological characteristics of this species, which tends to fly in groups, has a low flight altitude, and is active in areas very close to aircraft movement paths.

The habitat around the airport, which consists of wetlands, artificial lakes, and low vegetation, also contributes to increased bird activity in the operational airspace. Thus, the research hypothesis stating that there are bird species with a high risk of bird strikes to flight safety at Kalimantan Airport can be accepted.

As a follow-up to these findings, it is recommended that Kalimantan Airport management implement a comprehensive habitat management strategy to reduce the attractiveness of the surrounding environment to birds, such as draining non-functional water bodies, regulating grass height, and controlling natural food sources. Additionally, the formation of a specialized task force (wildlife hazard management team) is crucial to ensure systematic mitigation implementation, including routine reporting and evaluation. The use of technology such as avian radar is also recommended to detect bird flock movements in real-time and support quick and accurate operational decision-making. These measures are expected to reduce the frequency and risk of bird strikes, thereby enhancing operational safety at Kalimantan Airport in a sustainable manner.

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