

Analysis Of Bird Strike Management Strategies at Zainuddin Abdul Madjid International Airport Lombok to Improve Flight Safety

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Article Info	ABSTRACT
<p>Article History: Submitted: July 11, 2025 Revised: July 15, 2025 Accepted: July 21, 2025</p> <hr/> <p>Keywords: Aviation Safety, Bird Strike, Management Strategy, Lombok Airport, Wildlife Hazard</p>	<p><i>The rapid growth of air transportation in Indonesia presents challenges to flight safety, particularly the recurring threat of bird strikes. Zainuddin Abdul Madjid International Airport Lombok (BIZAM), as the primary aviation hub in West Nusa Tenggara, frequently experiences such incidents due to its proximity to bird-attracting environments such as grasslands, rice fields, and water bodies. This study aims to analyze the causes of bird strikes and evaluate current mitigation strategies. A qualitative descriptive method was employed, involving direct field observation, interviews with airport safety personnel, and review of internal documents such as bird strike logs and safety reports. The research was conducted during the author's On-the-Job Training (OJT) at BIZAM for five months in 2024. The findings revealed three documented bird strike incidents during the observation period, occurring near the runway and apron areas during take-off and landing phases. While current deterrent measures such as vehicle patrols and sirens are in use, they are largely ineffective in the long term. The absence of real-time monitoring systems, data integration, and inter-agency collaboration contributes to the vulnerability. This study recommends the implementation of habitat management, predictive data modeling, and radar-based detection tools to enhance flight safety and align with international aviation standards.</i></p>

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INTRODUCTION

The aviation sector in Indonesia has become one of the fastest-growing modes of transportation, offering efficiency, speed, and comfort. It plays a vital role in connecting regions and supporting economic growth. Air transport is often chosen due to its time-saving nature and reliability [1]. As demand increases, airports are experiencing higher passenger volumes. This surge underlines the significance of maintaining flight safety across the nation [2]. According to Law No. 1 of 2009 on Aviation, airports are designated land or water areas equipped with aviation safety and security facilities, intended for aircraft operations, passenger and cargo handling, and intermodal transfers.

Zainuddin Abdul Madjid International Airport Lombok (BIZAM), located in Central Lombok, West Nusa Tenggara, serves as a vital international gateway for the region. Ensuring aviation safety at this airport is critical, considering not only internal operational procedures but also external environmental factors. One major concern is the presence of obstacles, including both natural and man-made structures, that could interfere with flight paths. Obstacle height management around the airport must follow regulations aligned with the Airport Reference Point (ARP). In addition to obstacles, bird strike incidents are another significant threat that compromises aviation safety [3].

Bird strikes refer to collisions between flying birds and aircraft, which can occur during any phase of flight, particularly during take-off and landing. These incidents can lead to mechanical failures, operational delays, and pose serious risks to passenger safety. At BIZAM, bird strike is among the top five reported hazards, alongside equipment damage, laser attacks, foreign object debris (FOD), and severe weather conditions [4]. The financial impact of such incidents includes repair costs, flight cancellations, and reputational damage to airlines and airports.

The probability of bird strikes is highest during critical flight phases due to low altitude and bird activity around the airport vicinity [5]. Effective bird strike prevention measures include habitat management, use of deterrent devices such as predator sounds and lasers, and ongoing monitoring with real-time radar [6]. These efforts aim to reduce airport attractiveness to birds while preserving ecological balance.

News from Eksis NTB (2024) highlighted a bird strike involving a Citilink aircraft on May 6, 2024, forcing it to return to BIZAM at an altitude of 5,500 feet. Although the aircraft remained airworthy, the incident raised safety concerns. Another case in 2017 involved a Lion Air JT823 flight that suffered nose cone damage due to a bird strike upon departure to Surabaya. These events underline the urgency of strategic intervention in bird strike mitigation at BIZAM.

Previous studies support the importance of comprehensive risk management in addressing bird strike threats. Sadono et al. (2021) examined wildlife hazard management at Bali Baru Airport, revealing the need for detailed mitigation planning. Putri & Fakhrudin (2022) assessed the Safety Management System (SMS) at Sultan Muhammad Kaharudin Airport and emphasized human resource optimization in hazard identification and corrective actions. Based on the background above, this study is titled: “Analysis of Bird Strike Management Strategies at Zainuddin Abdul Madjid International Airport Lombok to Improve Flight Safety”.

METHODS

This study applied a qualitative descriptive approach to analyze bird strike mitigation strategies implemented at Zainuddin Abdul Madjid International Airport Lombok (BIZAM). The method was selected to gain in-depth insights into operational practices, challenges, and institutional responses regarding bird strike risks. The study was conducted over five months in 2024 during the author’s On-the-Job Training (OJT) program at BIZAM.

Research Design

The research involved three main techniques: direct field observation, structured interviews, and document analysis. Observations were conducted during routine patrols and airside inspections. Interviews were held with personnel from the Safety Management Unit, Apron Movement Control, and Airport Rescue & Fire Fighting (ARFF). Documentation reviewed included bird strike logs, safety reports, and SOPs. This multi-source design helped triangulate

data for accuracy and reliability.

Research Variables

- a. Independent Variable (X): Bird strike mitigation strategies, including patrols, deterrents, and habitat control efforts.
- b. Dependent Variable (Y): Aviation safety, assessed through incident frequency, maintenance reports, and operational disruptions [7].

Data Collection Techniques

- a. Interview: Structured interviews used open-ended questions to assess current practices and perceptions of airport safety personnel [8].
- b. Observation: Conducted at airside locations focusing on bird activity zones, patrol frequency, and control tool deployment.
- c. Document Study: Reviewed official documents such as strike reports and operational logs to assess consistency and trends [9].

Instruments

Instruments used included:

- a. An interview guide developed based on airport safety literature.
- b. An observation checklist to record time, species, and location of bird activity.
- c. A documentation matrix to classify strike events, species involved, and damage levels.

Data Analysis Technique

Thematic analysis was used to process qualitative data following these stages:

- a. Data Reduction: Selecting and simplifying relevant information.
- b. Theme Coding: Grouping data by themes such as “response effectiveness” or “habitat risk.”
- c. Interpretation: Comparing field data with prior research to derive conclusions [7].

A visual flow of the research process is presented below:

Field Observation → Interviews → Document Review → Data Collection → Data Coding → Thematic Analysis → Validation (Triangulation) → Conclusion & Recommendation.

Gap Analysis

Previous studies such as Sadono et al. (2021) and Putri & Fakhrudin (2022) emphasized general wildlife hazard frameworks but lacked specific analysis of airport-level operational constraints. This study fills that gap by focusing on BIZAM’s unique environmental conditions, daily operational limitations, and strategic implementation capacity an area not yet evaluated comprehensively in existing literature.

RESULT AND DISCUSSION

Zainuddin Abdul Madjid International Airport Lombok (BIZAM) serves as the main aviation gateway for West Nusa Tenggara with facilities capable of accommodating up to seven million passengers annually. Despite its modern infrastructure, the airport faces persistent threats from bird strikes due to environmental factors surrounding the area, such as unmanaged grasslands, nearby rice paddies, and water bodies like Batujai Dam. These locations attract various bird species, particularly during early morning and late afternoon when flight activity peaks.

Wildlife Observation and Risk Mapping

Field observations conducted during the author’s OJT program revealed frequent sightings of species such as *Charadrius javanicus*, *Glareola maldivarum*, *Ardea purpurea*, *Tyto alba*, and *Elanus caeruleus* within close proximity to critical flight zones like runways and aprons. These birds often appear in flocks and exhibit high mobility, increasing the risk of mid-air collisions during take-off and landing phases.

Reported Bird Strike Incidents in 2024

According to the Safety Management System (SMS) at BIZAM, three significant bird strike incidents were reported during 2024. Although these incidents did not result in aircraft damage, they caused operational delays and triggered emergency inspections.

Table 1. Reported Bird Strike Incidents at BIZAM in 2024

Date	Airline	Location	Bird Species	Impact
March 5	Super Air Jet	Final Approach	Raptor (unspecified)	No damage, visual remains found
October 23	Airbus A320	Landing Phase	<i>Tyto alba</i> (Barn Owl)	Engine hit, safety check conducted
November 3	Batik Air	Pushback Area	Unknown species	Flight returned to apron, inspection

These cases underline the financial and operational burden caused by bird strikes, even when physical damage is avoided.

Evaluation of Current Mitigation Strategies

The airport currently employs conventional methods such as routine patrols using vehicles equipped with sirens[10]. However, interviews with operational staff revealed that these measures are only temporarily effective, as birds often return shortly after deterrent efforts cease. There is no deployment of acoustic deterrents, predator sound systems, or real-time radar detection. Furthermore, the absence of a centralized database for tracking bird species and incident patterns limits strategic decision-making.

Comparative Analysis with Other Airports

To understand the effectiveness of mitigation efforts, this study compares BIZAM's strategies with those implemented at Bali Baru and Hang Nadim Batam airports, both of which are considered more advanced in bird strike management.

Table 2. Comparative Analysis of Bird Strike Mitigation Strategies

Mitigation Strategy	BIZAM	Bali Baru Airport	Hang Nadim Batam
Routine Patrols	Yes	Yes	Yes
Siren Usage	Yes	No	No
Acoustic Deterrents	No	Yes	Yes
Habitat Modification	Inconsistent	Regular and planned	Regular and planned
Radar-based Monitoring	No	Yes	Yes
Wildlife Hazard Database	Not available	Available and updated	Available and updated
Inter-agency Collaboration	No	Yes (with forestry dept.)	Yes (with environment agency)
Staff Training Program	Minimal	Structured and periodic	Structured and periodic

The comparison shows that BIZAM's strategy remains reactive and technologically underdeveloped. Other airports have integrated wildlife hazard mitigation into their Safety Management Systems (SMS) with better results in bird strike reduction.

Strategic Improvement Recommendations

For BIZAM to effectively mitigate bird strikes, a shift from reactive to predictive and integrated approaches is required. The establishment of a centralized bird activity database, regular staff training on bird behavior and equipment usage, and procurement of modern detection systems such as radar and acoustic devices are essential. In addition, collaboration with wildlife and environmental agencies is necessary to manage habitats beyond the airport boundary.

Environmental Characteristics and Bird Attraction

The geographical surroundings of BIZAM present an ecological environment that is highly attractive to birds. During fieldwork, it was noted that unmanaged grass, open water areas, and agricultural lands specifically rice paddies are significant factors contributing to the concentration of bird populations near the airport. These natural elements serve as food sources and nesting grounds, making mitigation efforts more complex. Additionally, environmental features such as shrubs near the runway, puddles around taxiways, and wetland vegetation near the perimeter fence further support bird activity. These features were repeatedly observed during daily OJT patrols, especially between 05:00–08:00 and 16:00–18:00 local time, which coincides with peak bird and aircraft movements.

Bird Species Identification and Activity Patterns

From on-site documentation, the following species were most commonly identified during the five-month OJT period:

- a. *Charadrius javanicus* (Javan plover)
- b. *Glareola maldivarum* (Oriental pratincole)
- c. *Ardea purpurea* (Purple heron)
- d. *Ardeola speciosa* (Javan pond heron)
- e. *Tyto alba* (Barn owl)
- f. *Elanus caeruleus* (Black-winged kite)

The behavior of these species often involved low-altitude gliding or hovering close to the runway strip, especially when the grass had not been trimmed or water drainage was poor. Owls (*Tyto alba*) were mostly observed during early morning and dusk, while herons and kites were frequently spotted around stagnant water zones and during overcast weather.

Observational Data and Safety Implications

Visual data captured by the Safety Management Unit and corroborated through interviews confirmed that the same risk zones notably the southern runway end and apron boundary near cargo gates were consistently marked as high-risk zones. Yet, there is no digital mapping or pattern tracking database to assess trends or direct intervention.

The impact of bird strikes, although not always resulting in damage, includes:

- a. Operational delays due to mandatory inspections.
- b. Disruptions in departure sequences.
- c. Temporary closure of taxiways for clean-up or patrol.
- d. Stress and alert fatigue among airside safety teams due to unpredictable bird movements.

Institutional Limitations and Strategic Gaps

The analysis revealed several institutional weaknesses:

- a. Lack of structured wildlife hazard protocol in SMS documentation.
- b. Budget allocation for bird strike prevention is minimal and not sustained.
- c. No training modules on bird species recognition, behavior tracking, or use of modern deterrents.
- d. Absence of routine reporting or coordination with the Ministry of Environment or local conservation units.

Compared to Hang Nadim Batam and Bali Baru Airport, which have integrated bird strike risk into strategic planning and adopted radar tools, BIZAM remains operationally reactive and isolated in its mitigation efforts.

Strategic Model Suggestion

A proposed model for BIZAM's improvement includes:

- a. Wildlife hazard mapping: Use daily logs to identify and digitize high-risk zones.
- b. Radar or motion-sensor integration: To detect flocks or individual birds in real-time.
- c. Ecological collaboration: Involve local environmental NGOs and forestry departments to manage the outer perimeter habitats.

- d. Dedicated task force: A specialized team within SMS focusing solely on wildlife threats.
- e. Performance tracking: Include wildlife incidents in monthly safety KPI reviews.

CONCLUSION

Bird strikes remain a persistent and serious threat to flight safety at Zainuddin Abdul Madjid International Airport Lombok (BIZAM), primarily due to the airport's surrounding environment, which includes grass fields, rice paddies, and nearby water bodies. These conditions attract various bird species such as *Tyto alba*, *Charadrius javanicus*, and *Glareola maldivarum*, especially near critical flight paths like the runway and apron. Field observations and safety reports throughout 2024 confirmed three official bird strike incidents, none of which caused structural aircraft damage but did lead to operational delays and safety inspections.

Current bird strike mitigation strategies at BIZAM mainly involving patrols and siren use are insufficient for long-term risk reduction. These reactive measures are not supported by modern technologies such as real-time radar, acoustic deterrents, or predictive modeling. In addition, the absence of a centralized wildlife hazard database and lack of coordination with environmental agencies hinder the airport's ability to develop sustainable and data-driven prevention strategies.

For substantial improvement, the airport must implement a comprehensive risk mitigation framework that includes habitat management, strategic monitoring, and institutional integration within the Safety Management System (SMS). Investment in modern deterrent equipment, staff training, and inter-agency collaboration is also critical. This study contributes valuable insights to airport operators by highlighting operational weaknesses and proposing targeted improvements aligned with international best practices. Furthermore, the findings serve as a policy reference for civil aviation regulators in formulating national guidelines for wildlife hazard management at airports across Indonesia

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