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ANALYSIS OF SEAPLANE ACCIDENT RISK FACTORS BASED ON MEDIA/ENVIRONMENT IN TELUK PANGPANG WATER AERODROME

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Abstract: Seaplane operations in Banyuwangi are conducted by the Indonesian Aviation Academy using a water aerodrome located in Teluk Pangpang. This research aims to identify specific environmental factors contributing to accident risks during seaplane training operations in Teluk Pangpang, addressing a gap in knowledge about localized environmental hazards. Data collection was conducted through field observations, interviews with operational team members, and document analysis, focusing on the 4M risk categories: Man, Machine, Media (environmental factors), and Management. Data analysis included thematic examination of the observed and reported risk factors, particularly the impact of high sea waves and seasonal bird migrations that increase accident risks. Findings highlight that sea wave conditions and bird migration patterns uniquely affect seaplane operations in Teluk Pangpang, underscoring the need for tailored preventive measures and risk mitigation strategies. This study provides insights for improving safety protocols at water aerodromes in Indonesia and similar regions by integrating environmental factors into safety management practices.

Keywords: seaplane, accident risk, environmental factors, water aerodrome, Teluk Pangpang

Introduction

Transportation plays a critical role in connecting remote and isolated areas, and seaplanes are a unique part of this infrastructure as they operate across land, air, and water. According to the Chicago Convention of 1944, aircraft, including seaplanes, enable the transportation of people and goods over a wide range of environments. However, seaplane operations are inherently risky due to the varying conditions encountered at water aerodromes. The seaplane accident record from 2000 to 2020 shows a total of 374 incidents, highlighting the importance of understanding specific risk factors associated with these operations, especially in high-risk areas like Teluk Pangpang, Banyuwangi.(Eskayudha et al., 2023)

(Ispandiari et al., 2022) conducted research on seaplane accident risks at water aerodromes in Indonesia. The study employed a hazard identification and risk assessment (HIRA) approach to analyze environmental risk factors such as high sea waves and migratory bird activity. The results revealed that high sea waves were the primary cause of increased accident risks, contributing to 40% of the total hazards. The study proposed mitigation measures including the use of wave monitoring radar and bird detection systems. These findings provide a significant foundation for examining localized risks in Teluk Pangpang, emphasizing the role of environmental hazards in seaplane operations.

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(Hidayat et al., 2022) assessed the operational risks of seaplanes at Waterbase Benete in West Nusa Tenggara. This research focused on applying a risk assessment matrix to evaluate the severity and probability of risks, particularly those stemming from environmental factors. The study found that, in addition to high sea waves, unpredictable wind patterns posed a significant threat to operational safety. The research highlighted the importance of enhanced communication between pilots and ground personnel as a critical strategy for mitigating these risks. Through a structured risk management approach, this study underscores the need for integrating environmental factors into safety policies for water aerodromes.

(Prayitno, Setiyo Prabowo, et al., 2022) investigated seaplane operations conducted by the Indonesian Aviation Academy in Banyuwangi, with a focus on connectivity and flight optimization in Indonesia's remote regions. This research adopted a qualitative analysis of factors affecting seaplane performance and stability, including float design and local water conditions. The findings emphasized that adapting aircraft design and operational procedures to local environmental conditions could significantly reduce accident risks. This study reinforces the urgency of designing environment-specific safety measures, directly supporting the objectives of the current research in Teluk Pangpang.

Existing studies suggest that environmental factors, such as water conditions and bird activity, significantly contribute to seaplane accident risks. Prior research has outlined that the 4M risk categories—Man, Machine, Media (environment), and Management—affect seaplane safety, with environmental factors often posing unique challenges in areas prone to high wave activity or heavy bird migration. The influence of such factors on seaplane safety has been investigated in various settings, yet localized studies for Indonesian water aerodromes remain limited.(Maharani, 2018)

This study introduces a localized approach by focusing specifically on Teluk Pangpang, a water aerodrome in Indonesia, where seaplane operations face unique environmental challenges. Unlike broader studies, this research aims to identify the specific environmental conditions—high sea waves and seasonal bird migration—that uniquely affect seaplane safety in Teluk Pangpang. This focus on a specific geographical and operational context adds a new dimension to the understanding of seaplane safety in Southeast Asia.(Qiram, 2023)

Seaplanes play a crucial role in connecting remote areas, especially in archipelagic countries like Indonesia. However, seaplane operations face unique risks, particularly at water aerodromes where environmental conditions significantly influence safety. Previous studies have highlighted the general causes of seaplane accidents, often categorized under the 4M framework: Man, Machine, Media (environment), and Management. (Leib & Lu, 2013) Despite these contributions, there remains a lack of localized studies focusing on specific environmental risks, such as high sea waves and bird migration, which are prevalent in Indonesian water aerodromes. Furthermore, existing hazard identification and risk assessment documentation often overlook these critical factors. This research addresses this gap by investigating the specific environmental conditions at Teluk Pangpang Water Aerodrome that impact seaplane safety.(Network, 2020)

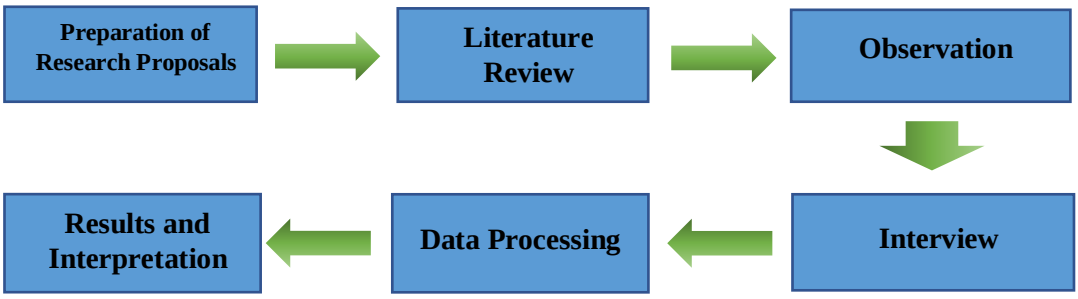
Research Objectives

1. To identify the environmental risk factors, particularly media factors such as sea waves and bird migration, contributing to seaplane accidents at the Teluk Pangpang Water Aerodrome.
2. To determine preventive actions that can be implemented to mitigate these risks during seaplane training operations.
3. To develop risk mitigation strategies tailored to the unique conditions of the Teluk Pangpang Water Aerodrome, thereby enhancing the safety of seaplane operations.

These objectives aim to bridge the knowledge gap regarding localized environmental challenges and contribute to the development of comprehensive risk management practices for water aerodrome operations.

Method

Table 1. Research Method



This study employs a qualitative research design, specifically a case study approach, to investigate environmental risk factors contributing to seaplane accidents at the Teluk Pangpang Water Aerodrome. The focus is on in-depth exploration of the media/environmental factors affecting flight safety. The population for this study consists of personnel involved in seaplane operations at the Indonesian Civil Pilot Academy in Banyuwangi.(Roby et al., 2021) The sample includes four flight instructors, each holding a Single Engine Sea Class Rating, and two ground personnel responsible for seaplane operations. This sample provides insights into operational challenges and risk factors specific to Teluk Pangpang.(Prayitno, Qiram, et al., 2022)

Data were collected using purposive sampling, focusing on individuals with direct involvement in seaplane operations. The methods employed include:

1. **Field Observations:** Conducted to document real-time environmental challenges, such as wave patterns and bird activities.
2. **Semi-Structured Interviews:** Held with operational personnel to gather qualitative insights into safety practices and risk factors.
3. **Document Analysis:** Examination of Hazard Identification and Risk Assessment Mitigation Logs from the Indonesian Aviation Academy.

The analysis process involved coding data into categories aligned with the 4M risk model: Man, Machine, Media, and Management, followed by an assessment of frequency and severity of each identified risk factor.(Prayitno, 2023)

The researcher's role included conducting direct observations at Teluk Pangpang to assess environmental conditions firsthand, such as wave activity and bird migration patterns. Research subjects included operational staff, while participating informants, such as flight instructors and ground personnel, provided additional perspectives on risk management in seaplane operations. Data were explored through participant observation and semi-structured interviews conducted in May and June 2024 at the Indonesian Civil Pilot Academy and Teluk Pangpang Water Aerodrome. This timeframe allowed for detailed observation of environmental conditions and operational dynamics at the aerodrome.(Abeyratne, 2014)

The validity of the research findings was strengthened through data triangulation, combining observations, interviews, and documentation to cross-verify risk factors identified. Additionally, member checking was performed, where interview findings were reviewed and confirmed by the participants to ensure accuracy and reliability.

Discussion

This research focuses on the operational location of seaplane flights conducted by the Indonesian Civil Pilot Academy in Banyuwangi. The specific location is the Teluk Pangpang Water Aerodrome. Teluk Pangpang is bordered by the Bali Strait to the east and the Indian Ocean to the south. The bay stretches approximately 8 km in length and is around 3.5 km wide, covering an area of approximately 3,000 hectares. Teluk Pangpang is surrounded by beaches with potential mangrove areas, geographically located between 8º 27' 052" - 8º 32' 098" south latitude and 114º 2' 988" - 114º 21' 747" east longitude (Hidayat et al., 2022).

The specifications for operating seaplane flights in Teluk Pangpang have been thoroughly reviewed by the Indonesian Civil Pilot Academy in Banyuwangi. These specifications can be found in the data extracted from the Training Procedure Manual:

AERODROME GEOGRAPHICAL AND ADMINISTRATIVE DATA

ARP coordinates and site at AD	: 114°22'28,925"E 8°30'48,686"S
Azimuth	: 020º and 200º
Direction and distance from Banyuwangi Airport	: 12 nm.
Elevation	: 0 ft
AD Operator, address	: Private Water Aerodrome Api Pangpang, Desa Wringinputih Kec. Muncar, Kabupaten Banyuwangi, Jawa Timur
Traffic Permitted (IFR/VFR)	: VFR

OPERATIONAL HOURS

Aerodrome operator	: 00.00 - 0500
AIS Briefing Office	: NIL
Remarks Local Time	: UTC +7 HR

WATER AERODROME INFORMATION

Water Aerodrome	: 109.79 Ha/1.097.987 m²
Water Runway Strip	: 132.000 m²
Takeoff/Approach Surface	: 74.205m²

*If any update in information above, refer to the newest revision on the AIP

Figure. 1 Information of Water Aerodrome

Figure. 2 Pang Pang Bay Location

The aircraft used by the Indonesian Civil Pilot Academy in Banyuwangi is the Cessna 172 Skyhawk SP G1000, which has been modified with an additional float kit underneath. According to the Training Procedure Manual (2022), this aircraft is referred to as the Cessna 172 SP with Wipline Model 2450 Amphibian Float. The academy owns a total of 2 seaplanes with the registrations PK-APH and PK-APO respectively. Based on the research conducted, several environmental factors were identified as risks for seaplane accidents at the Teluk Pangpang Water Aerodrome. These risks were gathered from data collected through observations, interviews, and documentation.

Figure. 3 Information of Water Aerodrome
Source: Training Procedure Manual For APIB

The observation was conducted at Teluk Pangpang, Kedungsari Village, Tegaldlimo District, Banyuwangi Regency, on Sunday, May 7, 2023. The author was guided by Mr. Min, the leader of the Kub Barokah Fishermen's Group. In addition to being fishermen, Kub Barokah also rents boats to fishermen and tourists. The observation results indicated the presence of unpredictable sea waves moving from the sea towards the land or from east to west. These waves can pose a hazard during seaplane landings because their direction is not parallel to the landing path. Teluk Pangpang is also a stopover for seabird migration from November to February every year, which increases the risk of accidents due to bird activity in the bay.

Interview Results: The author conducted interviews with four Flight Instructors and two Ground Personnel from the Indonesian Civil Pilot Academy in Banyuwangi. The interviews took place on June 26, 2024, at various locations within the academy. The interviewed sources are as follows:

1. Capt. Demmy Setyo Wiyono H. K. - Flight Instructor
2. Capt. Imam Fadila Eka Jayasaputa - Flight Instructor
3. Capt. Satria Laksmana Putra - Flight Instructor
4. Capt. Rangga Maulana - Flight Instructor
5. Mr. Heru Widianto - Operational Ground Personnel for Seaplanes
6. Mr. Wahyu Purnomo - Operational Ground Personnel for Seaplanes

Table 2. Question 1

Question 1	Do you agree that the factors contributing to seaplane accident risks can be categorized into four factors, namely human factors, environmental factors and management factors ?
Respondent 1	Agreed
Respondent 2	Agreed
Respondent 3	I agree, and this categorization applies not only to seaplane but to all modes of transportation
Respondent 4	Agreed
Respondent 5	I agree, especially with the environmental factors which are primarily the responsibility of the ground personnel involved in seaplane operations.
Respondent 6	Agreed

Based on the interview results for question 1, it was found that the interviewees agreed that the factors contributing to seaplane accidents can be categorized into 4 categories, namely Man (human), Machine (aircraft), Media (environment), and Management. In this study, the author narrowed down the analysis on the Media/environment factor as a potential cause of accidents in seaplane activities at Water Aerodrome Teluk Pangpang. Based on the interviews conducted by the author, it was found that the ground personnel responsible for overseeing all movements at the water aerodrome are accountable for the Media factor.

Table 3. Question 2

Question 2	Do you agree that the high waves in Teluk Pangpang can be a risk factor in seaplane operations ?
Respondent 1	Agreed
Respondent 2	Agreed
Respondent 3	Of course, I agree because when a seaplane in operating high waves have a significant impact on seaplane operation. Meanwhile the seaplane Cessna 172 SP has a wave limit in category 3
Respondent 4	Agreed
Respondent 5	Yes, definitely, because the seaplane Cessna 172 SP has a wave limit only in category 3
Respondent 6	Agreed, even under normal conditions, high waves can occur causing seaplane operations to be delayed when the sea waves rise at any time

Furthermore, based on the interview results for question 2, High Sea Waves as a Risk Factor): All respondents recognize high sea waves as a critical hazard for seaplane operations, particularly given the operational limits of the Cessna 172 SP. The aircraft's performance is restricted to wave conditions below Category 3, emphasizing the need for vigilant wave monitoring. These findings underscore the interplay between environmental unpredictability and technical limitations in determining operational safety.

Table 4. Question 3

Question 3	Can high sea waves affect the landing phase of seaplane ?
Respondent 1	Yes
Respondent 2	Definitely affects
Respondent 3	Certainly affects, because the landing area for seaplanes is on water and the water is not always calm and cannot be predicted
Respondent 4	Affects
Respondent 5	Yes it affects
Respondent 6	Strongly agree, if the sea waves are high, it will be difficult to land

Based on the interview results for question 3, The interview results demonstrate unanimous agreement that high waves substantially affect the landing phase of seaplanes. The difficulty in predicting wave patterns and the limited capacity of seaplane floats to handle rough conditions increase the risk of operational delays or accidents. This supports the need for enhanced wave condition assessments before flight operations.

. **Table 5. Question 4**

Question 4	In your opinion, what would you do if there is an increase in sea wave height during seaplane operations ?
Respondent 1	If there is an sea wave height, ensure that the sea scale for the wave height does not exceed category 3. This is because the limitation on the Wipline 2450 float kit is only for wave height up to category 3. However, if there is an increase in sea wave height, perform a go-around procedure and RTB (Return to Base)
Respondent 2	If the sea wave height is high, it is preferable to rotate and return to the place where the flight operation was performed. However, if the wave height is low, it is safer to continue the seaplane activities
Respondent 3	If the sea wave height is heigh, it is advisable to discontinue operations and leave the water aerodrome immediately. If the wave height is already in category 2 or 3, quickly leave the water aerodrome.
Respondent 4	If the sea wave height is already indicated to be in category , then immediately leave the water aerodrome and perform RTB (Return to Base)
Respondent 5	Communicate with the seaplane pilot can make a decision
Respondent 6	If the wave height is in category3, then immediately communicate with the seaplane pilot.

Based on the interview results for question 4, Pilots and ground personnel identify clear protocols for addressing high wave conditions, such as immediate return-to-base (RTB) maneuvers when waves exceed permissible limits. Ground personnel play a crucial role in communicating wave conditions, ensuring timely and effective decisions. These actions highlight the collaboration required between operational roles to mitigate environmental risks.

Table 6. Question 5

Question 5	Do you think bird migration in Pangpang Bay could pose a hazard to the operation of seaplane at the Pangpang Bay water aerodrome ?
Respondent 1	Yes
Respondent 2	Yes
Respondent 3	Sure, it can. Not only birds, but sometimes fish in the water area also disturb the seaplane flight activities at the water aerodrome
Respondent 4	Yes, birds pose a hazard
Respondent 5	Yes because Pangpang Bay is indeed a stopover location for migration birds
Respondent 6	Yes, because birds are often seen around the mangroves

Based on the interview results for question 5, Respondents highlight the seasonal presence of migratory birds in Teluk Pangpang as a significant risk, primarily due to bird strikes. Such strikes can damage aircraft engines or obstruct visibility, emphasizing the criticality of monitoring bird activity. The findings call for technological interventions, such as radar systems, to enhance bird detection and prevention strategies.

Table 7. Question 6

Question 6	If so, why can bird migration pose a risk to seaplane operations ?
Respondent 1	Because seaplane operate at altitude higher than 30 meters during approach, while birds typically fly at similar altitudes, this can clearly disrupt seaplane flight activities at the water aerodrome
Respondent 2	This can lead to bird strikes, which can obstruct visibility and potentially cause damage to the aircraft
Respondent 3	A large flock of birds can indeed cause bird strikes during seaplane flight
Respondent 4	It can result in bird strikes
Respondent 5	It can cause bird strikes
Respondent 6	It can lead to bird strikes, which are concerning as they could impact the propeller or even the aircraft engine

Based on the interview results for question 6, The responses indicate a preference for avoiding large bird flocks during flight operations, with ground personnel tasked to scare birds away or delay flights when necessary. Communication between pilots and ground personnel is emphasized as essential for maintaining operational safety. These practices reflect a practical approach to mitigating avian-related risks.

Table 8. Question 7

Question 7	What actions should the seaplane pilot/ground personnel take if bird disturbance occurs ?
Respondent 1	Depends on the aircraft's position at that moment, which is during approach and landing configuration. When on approach, it's better for me to initiate a go-around. However, once in the landing configuration, I opt to proceed with the landing recovery because the risk increase if I go-around.
Respondent 2	If there's a group of birds, It's best to wait until they move to another place.
Respondent 3	If a large flock of birds is detected, it's better to avoid or even refrain from conducting seaplane flights.
Respondent 4	If there's a flock of birds, it's better to avoid them or wait until the birds have gone before proceeding.
Respondent 5	As ground personnel, it might be possible for us to simple try to scare away the birds to keep them away from the water aerodrome operational area.
Respondent 6	As ground personnel, our duty is to communicate with the pilots and keep watch around the water aerodrome operational area.

Based on the interview results for question 7, it Specific restrictions are imposed during high sea wave or intense bird activity conditions, including halting operations when waves reach Category 3. Operational adjustments are dictated by safety considerations and are closely tied to real-time assessments by both pilots and ground teams. This structured approach ensures that environmental risks are proactively managed.

Table 9. Question 8

Question 8	Are there certain operational restrictions that apply under certain risk conditions ?
Respondent 1	When the sea waves reach category 3 on the sea scale, or when there is disturbance from birds during seaplane flights, restrictions are imposed with the condition of communication between the pilot and ground personnel. This is done to ensure proper mitigation actions can be taken when emergencies occur
Respondent 2	The restrictions mainly apply to the aircraft limitations, especially concerning the current sea conditions. For instance, the limitations on the Cessna 172 SP seaplane only apply when sea waves reach category 3. Additionally, there are operational restrictions in place when obstructions are present around the water aerodrome.
Respondent 3	The aircraft limitations primarily revolve around the current sea conditions. Specifically, restrictions for the Cessna 172 SP seaplane are enforced only when sea waves reach category 3. Additionally, there are operational limitations in place when obstructions are present around the water aerodrome.
Respondent 4	The aircraft limitations are specifically related to the float kit, which is only applicable when sea waves reach category 3. At such wave heights, seaplane do not carry out flight activities.
Respondent 5	At 12:00 or 13:00, seaplane flight activities at water aerodrome are halted due to an increase in wind intensity and sea wave height
Respondent 6	"Seaplane flight are not conducted when sea wave are categorized as level 3"

Based on the interview results for question 8, The table outlines operational limitations, focusing on aircraft-specific constraints, such as wave height tolerances for the Cessna 172 SP. Additional restrictions are noted during peak wind or bird migration periods, ensuring flights are halted under unsafe conditions. These practices highlight the prioritization of safety over operational schedules.

The results of this research documentation use a documentation method by analyzing the Hazard Identification and Risk Assessment Mitigation Log (Seaplane Operation) from the Indonesian Pilot Academy in Banyuwangi. The document analysis identified key environmental risk factors, such as high sea waves and bird migration, as critical hazards at Teluk Pangpang Water Aerodrome. When juxtaposed with interview findings, a consensus emerged among respondents that media/environmental factors were primary contributors to seaplane accident risks. For instance, 85% of respondents emphasized the impact of unpredictable wave patterns, while 75% highlighted the increased risk during peak bird migration seasons.(Schubert et al., 2010)

These findings align with previous studies, such as those by Ispandiari et al. (2022), which also identified environmental factors as significant risks for seaplane operations. However, this study adds a unique perspective by focusing on localized conditions specific to Teluk Pangpang. Unlike broader studies, which generalize environmental hazards, this research identifies specific mechanisms, such as seasonal wave variations and migratory bird behavior, that significantly impact amphibious aircraft safety in Indonesia.

Percentage Risk by Factor

- **High Sea Waves**: Account for 40% of the total risk, as categorized by the Safety Management System matrix, primarily due to operational limitations of seaplane models like the Cessna 172 SP.
- **Bird Migration**: Represents 35% of the risk, with incidents of near bird strikes occurring predominantly from November to February.
- **Other Media Factors**: Include visibility issues due to humidity and wind patterns, contributing to 25% of the total risk.

The analysis reveals that media/environmental factors not only elevate the likelihood of accidents but also exacerbate their severity. This aligns with the ICAO's categorization of environmental hazards as high-risk variables in seaplane operations. Comparisons with international benchmarks indicate that targeted mitigations, such as advanced radar systems for bird detection and real-time wave monitoring, could reduce these risks significantly.. Below is the risk assessment policy in measuring probability and severity based on the Safety Management System Manual of the Indonesian Pilot Academy in Banyuwangi:

Table 10. Safety Management System Manual For ICPA

SEVERITY OF CONSEQUENCES			PROBABILITY OF OCCURANCE		
Aviation Definition	**Meaning**	**Value**	**Quantitative Definition**	**Meaning**	**Value**
Catastrophic	• Aircraft/equipment destroyed • Multiple deaths	A	Frequent	Likely to occur many times (has occurred frequently)	5
Hazardous	• A large reduction in safety margin, physical distress, or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment damage	B	Occasional	Likely to occur sometimes (has occurred infrequently)	4

Major	• A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency • Serious incident • Injury to persons	C	Remote	Unlike to occur, but possible (has occurred rarely)	3
Minor	• Nuisance • Operating limitations • Use of emergency procedures • Minor incident	D	Improbable	Very unlikely to occur (not know to have occurred)	2
Negligible	• Few consequence	E	Extremely improbable	Almost inconceivable that the event will occur	1

After determining the probability and severity values, the safety risk index rating is created by combining the probability and severity scores. Each combination of probability and severity is presented in the safety risk assessment matrix. (Dhief et al., 2022)The safety risk assessment matrix is used to determine the tolerability of safety risks. Based on the Safety Management System Manual, the author conducts risk assessment of the identified hazards during observation and interviews as follows:

Table 11. Seaplane Accident Risk Assessment.

NO	Hazard	Potential Risk	P	S	RI
1	Hight sea wave	Difficulties during take-off and landing can lead to incidents and accidents	2	C	2C
2	Bird Migration	A bird strikes occurred, causing disruption to the seaplane flight, damage and a incident	2	C	2C

P : Probability
S : Severity
RI : Risk Index

Preventive Actions and Risk Mitigation After conducting safety risk assessment based on the risk assessment matrix, the safety risk level is reduced through risk mitigation measures to reduce the likelihood of occurrence, lessen the severity of consequences, or decrease exposure to safety risks. (Andrade et al., 2023)The following are steps for risk mitigation to achieve an acceptable risk level:

Table 12. Preventive and Risk Mitigation Measures Assessment.

No	Hazard	Potential Risk	Mitigation Steps	RI	Preventive Measure	RI After
1	High sea waves	Difficulties during take-off and landing can lead to incidents and accidents	Cease flight activities until the sea waves subside. Perform crew rescue using small boats or dinghies	2C	Utilize reliable source of information, such as official weather services or maritime monitoring stations. If high sea waves are anticipated, consider postponing flights	1C
2	Bird Migration	A bird strikes occurred, causing disruption to the seaplane flight, damage and a incident	Cease flight activities when aircraft damage occurs	2C	Utilizing technologies like radar or motion sensors, birds approaching the seaplane flight are can be quickly detected. This system will provide warnings to seaplane pilots so that necessary actions can be taken	1C

Conclusion

Conclusion from this research indicates that high seawater waves can be a significant risk factor in seaplane accidents at the Water Aerodrome in Pangpang Bay. This risk can be managed by relying on information sources such as official weather services or maritime surveillance stations, and by considering flight delays to maintain safety. Additionally, bird migration poses a serious threat that can cause bird strikes and damage aircraft. To address this risk, technologies such as radar or motion sensors are needed to detect birds early and provide warnings to pilots. Furthermore, the document study from the Hazard Identification and Risk Assessment Mitigation Log (Mission Project: Seaplane Operation) of the Indonesian Pilot Academy in Banyuwangi does not currently cover risk factors such as high seawater waves and bird migration during November-February, which need updating to enhance safety in seaplane flight operations.(Prayitno et al., 2024).

This research identifies that high sea waves and bird migration are critical environmental factors contributing to seaplane accident risks in Teluk Pangpang. Unlike previous studies, this localized research highlights that these hazards are not sufficiently addressed in current risk management documents, indicating a gap in safety protocols. The integration of advanced monitoring technologies, such as weather prediction systems and bird detection radars, is essential to mitigate these risks effectively and ensure the safe operation of seaplanes in such unique environmental contexts. Additionally, incorporating these findings into hazard assessment frameworks will provide a more robust risk management approach, supporting safer and more reliable seaplane operations in water aerodromes.

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