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Risk Analysis and Mitigation Strategies for Nava Base Logistics Using the Delphi-HOR Combination

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ABSTRACT

This research is conducted to ensure that base logistics can optimally support KRI operations. The purpose of this research is to identify risk factors, assess the current risk level of base logistics, and develop risk mitigation strategies. With a special focus on Indonesia's maritime borders. Using a descriptive statistical qualitative approach, this research combines Delphi-HOR (House Of Risk) to support its analysis. The risk factors affecting base logistics are divided into: naval base facilities factor, environment factor, and infrastructure support factor. This research identifies 4 sub-factors of naval base facilities, 5 sub-factors of the environment, and 4 sub-factors of infrastructure support. Based on the severity and occurrence level of risk in the study, it shows that 1 sub-factor is at the low level, 5 sub-factors are at the medium level, and 8 sub-factors are at the high-risk level. The results of the factor identification by Delphi combined with HOR phase 1 show that there are 14 risk agents (A) and 14 risk events (E) that emerged. According to the ARP calculation, there are 5 risk agents (A) that contribute the most. The results of HOR phase 2 yielded 7 preventive actions used as risk mitigation strategies. The Delphi-HOR combination is capable of producing feasible mitigation strategies to address the existing risk factors.

1. Introduction.

The presence of KRI in Indonesia's border areas is essential to maintain the security and sovereignty of Indonesia's maritime territory. The operation of KRI elements at sea requires very thorough planning, closely related to the readiness of KRI elements, the readiness of KRI personnel, and the readiness of logistical support at the TNI AL base.

Logistical support is one of the keys to the success of operations in the operational area because without careful planning, KRI operations cannot run smoothly (Almubaroq et al., 2023). Logistics ensures and supports the availability of the necessary resources for the execution of operations at the right time and place. So far, in carrying out replenishment, KRI elements have had to conduct replenishment at bases farther away compared to TNI AL X base. As a result, the patrol and replenishment patterns are considered inefficient because they require more time and planning for the rotation of KRI units to maintain their presence in the operational area.

The current state of logistical readiness at base X has many high risks that could hinder the ideal execution of base logistics as expected. By maximizing Base X, it is expected to support KRI operations in the border area more efficiently without wasting time on resupply.

It is expected that determining the risk factors of base logistics is very important for maintaining an efficient supply chain and for enhancing base logistics activities. The existing risks can impact logistics performance and require management analysis to be able to unravel them and how to create mitigation strategies. Implementing risk evaluation and mitigation systems to identify, analyze, and respond to risks effectively (Rusdiansyah and Ibrahim, 2020). The calculation of costs arising from risks can help decision-makers prioritize risk management ac-

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tivities and ensure efficient supply chain operations (Huth and Düerkop, 2019).

Research that offers four stages in evaluating risks and a risk mitigation system based on the House Of Risk (Rusdiansyah and Ibrahim, 2020). Developing a risk management model by integrating several tools to enhance the decision-making process in managing risks associated with the implementation of Lean Manufacturing. Providing a quantitative analysis at each step of risk management, facilitating the identification, analysis, and evaluation of potential risks (Widiasih, Karningsih and Ciptomulyono, 2015). Offering an analysis of severity levels in the impact of risks that occur and identifying factors that hinder logistics activities (Sarkar, Shankar and Kar, 2023).In this study, a descriptive statistical qualitative approach is used, supported by logistics, risk, and risk mitigation theories. The methodology of this research combines the Delphi method and House Of Risk (HOR) supported by a panel of 16 experts.

The selection of base X, which is located near the Indonesian border and has a strategic position, is considered efficient in supporting the logistics of KRI conducting operations in border areas, making it the main focus of this research. There are several stages carried out in this research. First, conduct the identification of risk factors present at base X. Second, create the current risk level based on severity and occurrence, which can serve as the basis for the importance of conducting this research. Third, develop mitigation strategies for the risk factors that emerge from the identification.

This research has several contributions. First, this research provides an overview of the current conditions regarding various risk factors that can affect KRI operations by hindering base logistics. Second, developing mitigation strategies for the risks that arise in base logistics activities to make KRI operations more efficient. Third, this research serves as one of the suggestions and inputs to become a basis for improving logistics functions by reducing existing risk factors with the mitigation strategies that have been developed (Bhuiyan, 2024).

2. Literature Review.

2.1. Logistics Theory.

Fundamental logistics theory includes several concepts and frameworks designed to enhance the transportation and management of commodities within the supply chain. Military logistics theory includes diverse tactics and models designed to enhance supply and support systems essential for military operations (Yanuarico et al., 2024). This encompasses the planning, execution, and regulation of the movement and storage of products, services, and information from the origin to the consumption point to fulfill the needs of military forces. This notion is essential to guarantee that military forces are sufficiently equipped and supported throughout operations, which directly influences their efficacy and success. Military logistics management is a complicated and essential subject, serving a strategic function in facilitating the efficient execution of military operations (Almubaroq et al., 2023). Military logistics management encompasses several strategies aimed at optimizing the supply chain and ensuring effective resource allocation, particularly in adverse circumstances. Techniques for assessing logistics efficiency encompass hierarchical system analysis and dynamic programming to enhance resource allocation and route planning (Dachkovskyi, 2021). By implementing this strategy, the military can delineate the essential procedures to facilitate operations, from assessing requirements to final delivery at the designated location. This algorithmic method minimizes distance, time, and vehicle use, hence optimizing depot management and logistics distribution (Kesik and Altıntas, 2023). This method facilitates a more acute emphasis on efficiency in material management, transportation management, and warehouse optimization.

Transportation logistics in military operations are a crucial element that plays an important role in supporting the success of missions on the battlefield (Almubaroq et al., 2023). This process includes planning, managing, and delivering military cargo to the operational zone, often facing significant challenges such as delays, security threats, and uncertainty in the field situation.

2.2. Base Logistics.

Indonesian naval bases are essential to national logistics, enabling effective and coordinated supply distribution throughout the archipelago. This involves optimizing logistics operations to maintain a reliable supply chain (Mukhlis et al., 2024). The functions of the base in operational activities are rebased, refueling, replenishment, repair, rest, and recreation (Pandjaitan, Suwarno, and Gunardi, 2019). Naval bases provide holding facilities, supply support, and maintenance and repair services, which are crucial for the operational readiness of naval vessels.

As a key element in the Sistem Senjata Armada Terpadu (SSAT), the Naval Base provides a variety of facilities, including detention facilities for ships, supply support encompassing logistics and materials, as well as maintenance and repair services. The availability of these facilities and services is crucial to ensure the operational readiness of naval vessels, enabling them to carry out tasks such as maritime security patrols, law enforcement at sea, and defense operations. Thus, the effectiveness of the base's functions directly impacts the Indonesian Navy's ability to maintain security stability in Indonesian waters and surrounding areas.

2.3. Risk Theory.

Basic risk theory encompasses a wide spectrum of disciplines and applications, with a focus on the identification, assessment, and mitigation of potential threats to various systems and processes. This theory is fundamental in understanding how risks can be managed across various domains, from natural disasters to engineering projects. This theory emphasizes a holistic approach, integrating scientific, social, and economic perspectives to effectively address and communicate risk (Cerase, 2017). Risk is a measure of the probability and impact that occurs if the project's objectives are not achieved. The risk is a function of the likelihood and the impact it causes (Bartlett, 2004).

2.4. Mitigation Theory.

Risk mitigation denotes a strategy measure designed to diminish or control risk to an acceptable threshold across diverse circumstances. The objective of risk mitigation encompasses techniques designed to diminish prospective risks to an acceptable threshold across many domains; it also aids in preserving operational stability by ensuring that alternative or backup solutions are prepared for implementation when risks materialize (Meiryani, 2018). This risk mitigation aims to bolster resilience against diverse threats, including operational risks. Creating models to simulate future hazards facilitates the proactive identification of vulnerabilities and the development of preventive measures (Fedorovych et al., 2022). Mitigation occurs upon the identification of a risk; it necessitates a sequence of activities to effectively handle the risk. This pertains to multiple phases in risk mitigation, commencing with risk identification and culminating in the ultimate decision about risk management (Radiansyah et al., 2023).

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3. Methodology.

4. Delphi Method.

The Delphi Method, a systematic forecasting technique, was created by the RAND Corporation in the 1950s. This approach entails several iterations of questionnaires completed by a panel of experts, with feedback given after each round to enhance and harmonize viewpoints toward consensus. The Delphi method aims to attain consensus via a systematic approach of gathering and refining opinions and assessments from experts and practitioners over several rounds (Ilyas, Jin, and Ullah, 2023).

The strategy seeks to unify viewpoints by refining the range of evaluations, crucially achieving this while circumventing the biases and inaccuracies commonly linked to direct, in-person contacts (Zio and Maretti, 2015; Ahmad et al., 2021).

This study employs the Delphi technique to solicit and aggregate the perspectives of 16 experts in order to identify the risk variables influencing base logistics activities. This study identifies risk variables through the Delphi technique, commencing with a Pre-Delphi phase involving a literature review, followed by up to four rounds of Delphi until consensus is achieved.

5. Content Validation Indeks.

The Content Validity Index (CVI) is a significant method for assessing the dependability of an instrument's content and is well recognized across multiple research domains. It assesses the degree of consensus among experts regarding the representativeness or relevance of the items in the instrument, yielding insights into both the overall content validity of the instrument (Instrument-level CVI) and the validity of individual items (Item-level CVI or I-CVI). The expert evaluation of the representativeness or relevance of each item's content is the foundation for calculating the CVI (Almanasreh, Moles and Chen, 2018).

The mean and standard deviation are computed to evaluate factor convergence when analyzing the factors affecting the panel's consensus on the influence of elements on base logistics within a particular domain (during the Delphi round). A 5-point Likert scale enables the expert panel to assess the importance of each aim (Stancine et al., 2019). This study employed both the average scale-level content validity index (S-CVI/Ave) and the item-level content validity index (I-CVI) to assess content validity. The overall I-CVI score is divided by the number of items to calculate the S-CVI/Ave. S-CVI/Ave ≥ 0.90 signifies excellent content validity, whereas S-CVI/Ave ≥ 0.80 is deemed acceptable. The acceptable I-CVI is ≥ 0.78, calculated by dividing the number of experts who rate an item ≥ 3 by the total number of experts. Current research indicates that a new evaluation instrument must attain an I-CVI of at least 0.78 (78%) and a total CVI of at least 0.90 (90%) to be deemed legitimate (Marisa, 2021).

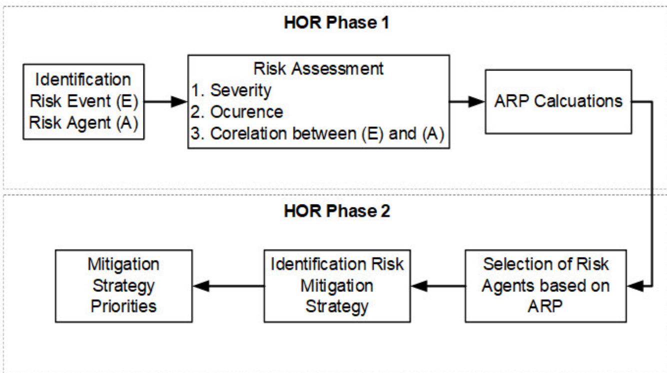
The S-CVI/Universe approach was not employed in this instance due to the potential distortion of results by the extensive size of the expert panel, rendering them unsuitable. This strategy neglects the possibility of random agreement among experts (Roya and Behrooz, 2017), highlighting the method's dependence on expert consensus without accounting for randomness in answers. In examining the elements affecting the panel's agreement on fundamental logistical risk factors in a particular area (during the Delphi rounds), both the mean and standard deviation were computed to assess factor convergence. The expert panel evaluated the significance of each aim using a 5-point Likert scale (Faisal and Apriliadi, 2021).

6. House Of Risk (HOR).

The House of Risk technique consists of two phases: HOR Phase 1 and HOR Phase 2. Risk analysis use the HOR phase 1 technique to identify probable risk events and agents, culminating in the categorization of risk agents into priority groups based on their significance aggregate risk potential (ARPj).

At this stage, the author also creates a risk level by taking the severity and occurrence values of risk agents and risk events, which are then displayed in the form of a matrix diagram. The impact scale for severity assessment is a value from 0 to 10 and the scale for the likelihood of occurrence.occurrence is a value from 0 to 10 and the correlation assessment scale includes values 0, 1, 3, and 9 (Pujawan and Geraldin, 2009). From the matrix diagram, it will be known how the current risk level and the feasibility of the investigated problem are.

Figure 1: Research Flow House of Risk.



Source: Author.

Phase 2 of the HOR stage focuses on designing mitigation measures aimed at addressing the causes or agents of priority category risks, culminating in the calculation of the total effectiveness to difficulty ratio (ETDk) to identify preventative actions, specifically mitigation techniques. The most effective mitigation strategy selected from the acquired strategies addresses the prevailing risk variables.

Table 1: Risk Event Correlation Value Scale with Risk Causes.

Number	Explanation
9	Showing a strong correlation between risk events and risk causes
3	Showing a moderate correlation between risk events and risk causes
1	Indicates a weak correlation between the occurrence of risk and the cause of the risk
0	Showing no correlation between the occurrence of risk and the cause of risk

Source: Pujawan and Geraldin, 2009.

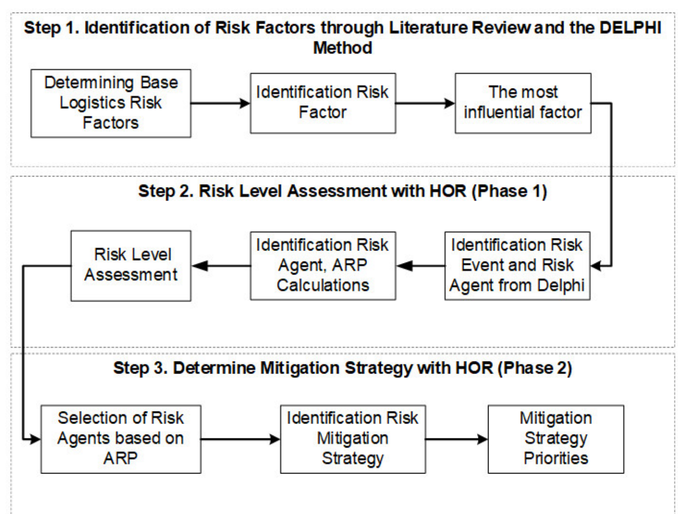
6.1. Conceptual Framework.

In this research topic, it is located at navy base X, which is on the maritime border of Indonesia. With the aim of identifying the risk factors that affect the implementation of base logistics and developing strategies to mitigate those risks. This research uses a descriptive statistical qualitative approach by applying a 3-stage decision-making process using a combination of the Delphi method and House Of Risk (HOR).

This analysis begins with the use of Delphi to identify risk factors, with data referring to the literature review of previous research, followed by Delphi rounds conducted by experts until consensus is reached. The Delphi survey was meticulously designed to collect data in each survey round and formulate impact assessment questions on a five-point Likert scale.

The subsequent step involves the identification of experts based on certain established criteria. Initially, the possession of specialized expertise and experience pertinent to their positions or participation in military strategy and agenda development, akin to that of a Navy Chief (Fletcher and Griffiths, 2020). Secondly, proficiency and experience pertinent to the research inquiry (Nguyen et al., 2022). Third, possessing a minimum of 10 years of professional expertise in the logistics sector (Khalilzadeh, Katoueizadeh, and Zavadskas, 2020). Fourth, comprehending the complexities surrounding the maritime boundary between Indonesia and the Philippines (Ramadhan, Yani, and Amaluddin, 2018). Fifth, a minimum academic qualification of a Master's degree (Quatrini Carvalho Passos Guimarães et al., 2016).

Figure 2: Conceptual Framework of Research.



Source: Author.

The conceptual framework developed in this study is presented in Figure 2. There are several objectives, namely:

- Identifying risk factors affecting base logistics using the Delphi method.

- Creating the current risk level based on severity and occurrence values.

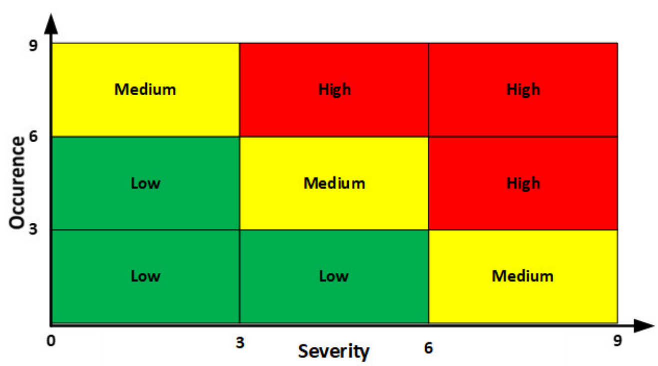
- Creating a risk mitigation strategy using HOR.

This research is further able to develop the process of identifying risk factors up to risk mitigation using a combination of the Delphi method and HOR. The application of the Delphi-HOR combination has advantages in validating the obtained data (Widiasih, Karningsih, and Ciptomulyono, 2015). The mechanism of this research model is illustrated in Figure 2 to answer several questions, namely research 1, 2, and 3.

Step 1: Identification of Risk Factors. The initial stage involves identifying base logistics risk factors. Taking the basis of factors from the results of a comprehensive literature review used as Pre-Delphi. The Delphi method plays a role in building consensus through a structured process of collecting and refining influential risk factors with CVI validity. The results from Delphi are then combined in phase 1 of the HOR method, as the identification of factors within HOR is replaced using Delphi, which employs the validated CVI results.

Step 2: Risk level Assessment. At this stage, the results of the Delphi factor identification are included in phase 1 of the HOR to determine the event risk and risk agents. After that, a risk assessment was conducted based on the severity, occurrence values, and the correlation assessment between the event risk and risk agent. Matrix risk level based on severity and occurrence values can be seen in Figure 3, and the risk level values can be seen in Table 2.

Figure 3: Risk Level Matrix Modified From (Louw and Esterhuyzen, 2022).



Source: Author.

The next step is to calculate the Aggregate Risk Potential (ARP) to identify the risk agents that contribute 75% of the cumulative ARP value (Pujawan and Geraldin, 2009). After that, the obtained ARP values are used to rank the risk agents for use in the HOR phase 2.

Table 2: Value of Risk Level.

Level	Score	Description	Level	Colour
3	6-9	High risk. It has been identified that the risk affecting base logistics activities has a significant impact and directly influences base logistics. An analysis is needed to address the risk so that it does not cause losses to base logistics.	High	
2	3-5.9	Providing a medium impact that has been identified will have a significant influence on logistics. In this condition, base logistics can still operate with some minor losses.	Medium	
1	0.1-2.9	At this low level, the existing risks have a small impact that does not affect base logistics.	Low	

Source: Modified from (Louw and Esterhuyzen, 2022).

Step 3: Determine Mitigation Strategy. In the final stage, which is determining the risk mitigation strategy, the process continues from the results of HOR phase 1 (Prasetyo, Retnani, and Ifadah, 2022). From the results of the identified risk agents, the next step is to identify Preventive Actions (PA). Once the risk agents are selected, the experts determine the Preventive Actions according to the existing risk genes. The assessment of this mitigation strategy includes: the correlation value between the risk agent and the mitigation strategy and determining the level of difficulty. Next, calculate the Effectiveness to Difficulty Ratio of Action k (ETDk) for each Preventive Action until obtaining a ranking of the Preventive Actions as the most consistent mitigation strategies to face emerging risks.

7. Results.

In this segment, we use the Delphi-HOR Methodology to analyze risks and mitigation strategies for emerging risks in base logistics. Initially, this process involves determining the risk factors that affect base logistics. Next, we assess the risk levels based on the severity and occurrence values present in the field conditions based on further identification from Delphi. Finally, develop mitigation strategies for the identified risks until consistent mitigation strategies are produced to address the emerging risks.

7.1. Identification of base logistics risk factors.

This section explains in a structured manner how the risk factor identification process is divided into three main factors: the factor of TNI AL base facilities, environmental factors, and infrastructure factors. Initially, the Delphi round will be conducted by 16 experts in the fields of logistics, planning, operations, and security to participate in the Delphi survey. The design of the Delphi survey questionnaire in the research is very important to gain insights and exploration about the objectives or criteria in each survey round. In the process, it begins with the collection of factors and sub-factors that have an impact on base logistics through a literature review of various sources that can be seen in Table 3.

Table 3: Factors and sub-factors of base logistics from the literature review.

Factor	Sub Factor	Code	References
Naval Base Facilities	Port Facilities	C1	
	Maintenance and repair facilities	C2	(Suryawan, 2023)
	Supply facilities	C3	(Naibaho, 2022)
	Personnel Facilities	C4	(Nursanto, Musani and Murniawan, 2021)
	Base facilities	C5	(Agustian and Bastari, 2019)
	Suppy warehousefacilities	C6	
Environment	Vulnerability of the region	C7	(Vander Hoorn and Knapp, 2015)
	Social conflict	C8	(Qian and Wang, 2023)
	The Influence of Maritime Security	C9	(Bottalico, 2019) (Sarkar, Shankar and Kar, 2023)
	Border violation	C10	(Agustian and Bastari, 2019)
	Threat from Other Countries	C11	(Edgerton, 2021)
	Limited resources	C12	(Kusi, 2015)
	Economic and Political Influence	C13	(Serrano *et al.*, 2023)
	The Influence of Weather	C14	(Moore, 2017)
	The influence of the pandemic and disasters	C15	(Panjehfouladgaran and Lim, 2020)
	The Influence of Regional Position	C16	(Jeevan *et al.*, 2020)
	Navigation vulnerability	C17	(Liu, Zhou and Sun, 2019)
Infrastructure Support	Port Capacity	C18	(Panjehfouladgaran and Lim, 2020)
	Port Facility Support	C19	(Wang and Wang, 2023)
	Use of Public Port	C20	(Liu, Zhou and Sun, 2019)
	Port equipment capabilities	C21	(Gurning and Cahoon, 2011)
	Port automation technology	C22	(Ilyas, Jin and Ullah, 2023)
	Port operational protocol	C23	(Afpriyanto *et al.*, 2023)
	Logistic Support	C24	

Source: Modification from various sources.

Round 1: In this first round, 16 selected experts provided answers to the questionnaire both directly and indirectly. This research outlines the study and its objectives, which include 24 sub-factors divided into 3 factors: 6 sub-factors related to naval base facilities, 11 sub-factors related to the environment, and 7 sub-factors related to supporting infrastructure. The analysis reveals that all sub-factors are capable of influencing base logistics activities, with expert evaluations above an average of 3 on a 1-5 Likert scale. The result of round 1 is that 4 sub-factors were eliminated (UA-CVI value ≤ 0.78 is eliminated), namely the sub-factors of social conflict, economic and political influence, port automation technology, and port operational protocol. From the results of round 1 with an I-CVI value ranging from 0.69 to 1. The results of round 1 left 20 sub-factors from the previous 24 sub-factors.

Round 2: The results of Delphi round 1 left 20 sub-factors to be continued in the second round, consisting of base facility factors with 6 sub-factors, environmental factors with 9 sub-factors, and infrastructure support factors with 5 sub-factors. Next, the results of Delphi round 2 indicated that 4 sub-factors were eliminated (UA-CVI value ≤ 0.63 is eliminated), namely supply warehouse facilities, threat from other countries, the influence of the pandemic and disasters, and use of public port. The results of the round 1 calculations with an I-CVI value ranging from 0.63 to 1. From the Delphi round 2, 16 sub-factors remain.

Round 3: The results of Delphi round 2 left 16 sub-factors to be continued in the third round, consisting of base facilities factor with 5 sub-factors, environment factor with 7 sub-factors, and infrastructure support factor with 4 sub-factors. After conducting round 3, it was found that 3 sub-factors were eliminated, namely base facilities, border violation, and the influence of regional position. Next, 13 sub-factors remain with I-CVI values ranging from 0.75 to 1. Of the 13 existing sub-factors, there are 4 sub-factors under the base facility factor, 5 sub-factors under the environment factor, and 4 sub-factors under the infrastructure support factor.

Round 4: The fourth evaluation round was conducted to assess the final validation. The consensus results were nearly unanimous, with an I-CVI value of 1 for almost all items, indicating 100% agreement among the experts. This resulted in an impressive S-CVI of 100%. Considering the excellent I-CVI value, this round effectively concludes the overall instrument validation phase, eliminating the need for further evaluation, with the final result of round 4 yielding 13 sub risk factors. All items fall into the valid or very valid category, reaching a consensus in the Delphi process. All the results of the Delphi round can be seen in Table 4 below.

Table 4: Summary of the Delphi round results.

Code	Sub Factors	Round 1			Round 2			Round 3			Round 4			New Code
		Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result	
C1	Port Facilities	4,50	0,94	Accepted	4,63	1,00	Accepted	4,63	1,00	Accepted	4,63	1,00	Accepted	C1
C2	Maintenance and repair facilities	4,13	0,81	Accepted	4,31	0,88	Accepted	4,44	1,00	Accepted	4,44	1,00	Accepted	C2
C3	Supply facilities	4,13	0,94	Accepted	4,38	0,88	Accepted	4,44	1,00	Accepted	4,44	1,00	Accepted	C3
C4	Personnel Facilities	4,44	0,81	Accepted	4,31	0,94	Accepted	4,38	1,00	Accepted	4,38	1,00	Accepted	C4
C5	Base facilities	3,88	0,88	Accepted	3,81	0,81	Accepted	3,75	0,69	Eliminated				
C6	Supply warehouse facilities	4,50	0,94	Accepted	3,88	0,63	Eliminated							
C7	Vulnerability of the region	4,13	0,88	Accepted	4,31	0,94	Accepted	4,38	1,00	Accepted	4,38	1,00	Accepted	C5
C8	Social conflict	3,75	0,75	Eliminated										
C9	The Influence of Maritime Security	4,44	0,94	Accepted	4,31	0,94	Accepted	4,38	1,00	Accepted	4,38	1,00	Accepted	C6
C10	Border violation	3,94	0,88	Accepted	4,06	0,94	Accepted	4,38	1,00	Eliminated				
C11	Threat from Other Countries	4,13	0,88	Accepted	3,69	0,69	Eliminated							
C12	Limited resources	4,38	0,94	Accepted	4,06	0,94	Accepted	4,38	1,00	Accepted	4,38	1,00	Accepted	C7
C13	Economic and Political Influence	3,75	0,63	Eliminated										
C14	The Influence of Weather	3,88	0,88	Accepted	3,94	0,88	Accepted	4,31	1,00	Accepted	4,31	1,00	Accepted	C8
C15	The influence of the pandemic and disasters	3,94	0,88	Accepted	3,81	0,69	Eliminated							
C16	The Influence of Regional Position	3,94	0,88	Accepted	4,25	0,94	Accepted	3,88	0,69	Eliminated				
C17	Navigation vulnerability	4,00	0,88	Accepted	4,06	0,88	Accepted	4,38	0,94	Accepted	4,38	0,94	Accepted	C9
C18	Port Capacity	4,13	0,88	Accepted	4,69	0,94	Accepted	4,69	1,00	Accepted	4,69	1,00	Accepted	C10
C19	Port Facility Support	4,56	0,88	Accepted	4,31	1,00	Accepted	4,38	0,94	Accepted	4,38	0,94	Accepted	C11
C20	Use of Public Port	4,44	0,88	Accepted	3,69	0,69	Eliminated							
C21	Port equipment Capabilities	4,38	0,94	Accepted	4,25	0,81	Accepted	4,38	0,94	Accepted	4,38	0,94	Accepted	C12
C22	Port automation technology	3,75	0,69	Eliminated										
C23	Port operational protocol	3,94	0,69	Eliminated										
C24	Logistic Support	4,50	0,94	Accepted	4,75	0,94	Accepted	4,75	0,94	Accepted	4,63	0,94	Accepted	C13

Source: Author.

7.2. *Risk Level Assessment.*

We are now in Phase 1 of the HOR stage of this discussion. The identification of the Delphi follow-up data yielded 13 predominant sub-factors. Subsequently, ascertain the catalog of risk events derived from identifying risk sources, specifying the nature of the risks (what), their locations (where), their origins (how), and their causes (why), to evaluate their potential influence on the seamless execution of fundamental logistics operations. This list of risk occurrences includes a severity value based on the impact of each circumstance on base logistics. The identification of risk sources is derived from the prior Delphi risk factor identification. The catalog of risk occurrences and their corresponding severity values is available at Table 4.

Table 5: Severity Value of Risk Event (E).

Risk Factor	Risk Event (E)	Severity	Code
Naval Base Facilities	There is no private dock	9	E_1
	Repair and maintenance facilities are lacking	4	E_2
	Limited supply facilities	7	E_3
	The personnel care facilities are lacking	2	E_4
Environment	Region vulnerable to security	5	E_5
	Unstable maritime security	7	E_6
	Aborder violation occurred	5	E_7
	The influence of the weather	5	E_8
Infrastructure Support	Navigation is lacking	4	E_9
	Docking area, accommodating public vessels	9	E_{10}
	Port services are insufficiently met	2	E_{11}
	The capabilities of the dock equipment are insufficient	2	E_{12}
	Support logistics stock is limited	7	E_{13}
	Fuel supply is limited	9	E_{14}

Source: Author.

After obtaining the list of risk events, the next step will be to identify the causes of the risk events, identifying the risk causes from the risk events that have been identified in the previous stage. The identified risk agents amount to 14 risk causes. The identification of the occurrence value of a risk agent indicates the frequency of occurrence of that risk agent, with the occurrence value being measured on a scale of 1-10.(Pujawan and Geraldin, 2009).

Conducting a correlation assessment between risk agents and risk events using a value scale of 0, 1, 3, and 9 (Pujawan and Geraldin, 2009). The calculation of the Aggregate Risk Potential (ARP) value is obtained from the multiplication of the severity value, occurrence value, and the correlation value between the risk event and the risk agent. After processing in HOR phase 1 and obtaining the ARPj value and ranking the risk agents based on the ARP value. The list of risk agents and occurrence values can be seen at Table 6.

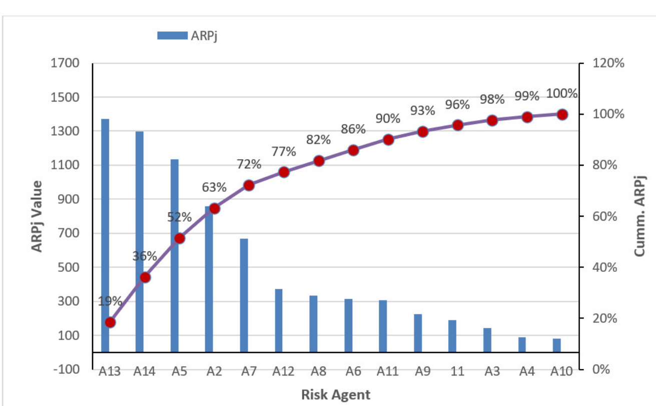
Table 6: Occurrence Value of Risk Agent (A).

Code	Risk Agent (A)	Occurence (O*j*)
A1	Policies tha are less supportive	3
A2	The lack of budget support	4
A3	Limitations of modern technology	8
A4	Human recouces that lack skills/ competence	7
A5	Dependency on third parties	4
A6	The high leve of illegal activities	6
A7	The limited security patrols in the area	5
A8	The lack of a border surveillance system	8
A9	Very rapid weather changes	4
A10	The lack of accurate weather forecast data	5
A11	Dependence on old technology for navigation	3
A12	Inadequate infrastructure	4
A13	Limited resources	5
A14	Limited supply chain	5

Source: Author.

After the severity and occurrence value data are obtained, the next step is to create a risk matrix based on the severity and occurrence values. From the existing risk level data using the appropriate index data (Ebile, Ndah and Wünsche, 2021). Before proceeding to the creation of the risk matrix, the ARP value will be calculated. The identified risk-causing agents with the highest ARPj values determined by the Pareto diagram will be input data in the HOR phase 2, which are the priority risk agents that will undergo mitigation actions. The risk agents Aj with their respective ARPj values are ranked from the highest to the lowest value, then the percentage of each ARPj against the total ARPj is calculated, and these percentages are then cumulatively summed until they reach 100%. The results of the Pareto diagram can be seen at Figure 4.

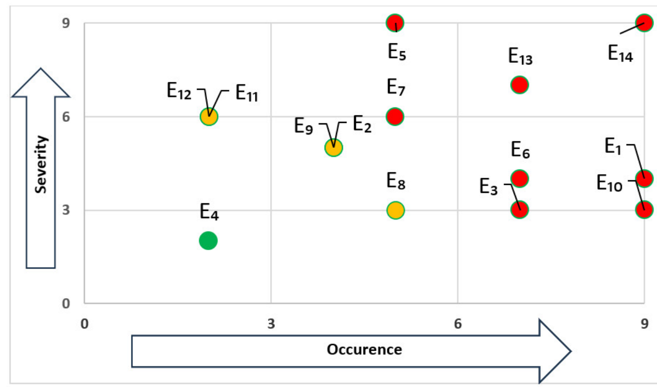
Figure 4: Pareto Diagram ARPj of All Risk Agents.



Source: Author.

From the risk matrix, several risk agents were identified with a combination of severity and occurrence values: 8 risk agents with high values, 5 risk agents with medium values, and 1 risk agent with a low value. From the overall risk agent values in the risk matrix, it shows a high-level risk. Given this condition, it is appropriate and certain to be used as a basis for developing risk mitigation strategies. The results of the risk matrix can be seen at Figure 5.

Figure 5: Risk matrix, combined severity and occurrence modified from (Ebile, Ndah and Wünsche, 2021).



Source: Author.

7.3. Determining mitigation strategies.

Once the ARP calculation has been completed, the risk agents making the greatest contribution will be selected. The risk agents contributing a total of 75% of the ARP value will proceed to HOR Phase 2 (Pujawan and Geraldin, 2009). Of the 14 risk agents based on the ARP values obtained, 5 risk agents can be selected according to the calculation results and proceed to HOR Phase 2.

The identification of mitigation strategies begins with the selection of risk agents using a Pareto diagram, resulting in 5 priority risk agents with the highest ARP values, namely: Limited resources, Limited supply chain, dependence on third parties, Insufficient budgetary support and Limited security patrols in the area. Next, mitigation strategies are determined based on the risk agents identified.

Calculation of the total effectiveness of proactive action k (TEk) and the effectiveness-to-difficulty ratio of action k (ETDk). Calculation of the correlation between risk agents and preventive actions (PAk) using values of 0, 1, 3, and 9, as well as a difficulty scale for implementing preventive actions of 3, 4, and 5 (Pujawan and Geraldin, 2009). Once all values have been obtained, the rank of proactive action k (Rk) can be determined.

The results of the mitigation strategy development show that certain preventive actions with the highest ETDk values are the most promising as steps to prevent various emerging risk agents. The ranking order is as follows: first, optimisation of priority resource allocation; second, enhancing cooperation among stakeholders; and third, developing a more mature and flexible supply chain, and so on in accordance with the ranking shown in Table 8. It can therefore be confirmed that, in line with the results of the calculations in Phase 2 of the HOR, the optimisation of priority resource allocation consistently emerges as a viable and consistent mitigation strategy for addressing various forms of risk that arise.

Table 7: Identification Mitigation Strategies.

PA_k	Mitigation Strategies
PA_1	Optimization of allocation priority needs
PA_2	Improving cooperation among stakeholders
PA_3	Development of the supply chain is more mature and flexible
PA_4	Mengembangkan sumber alternative
PA_5	Effective planning of patrol unit allocation
PA_6	Improving budget usage efficiency and evaluation
PA_7	Data driven and urgency based budget proposal

Source: Author.

Table 8: Ranking List of ETDk Relative to the Level of Difficulty (Dk).

PA_j	Preventive Action (PAk)	TEk	Dk	ETDk	Rk
PA_7	Optimization of allocation priority needs	14346	5	3936	1
PA_2	Improving cooperation among stakeholders	10206	3	3402	2
PA_4	Development of the supply chain is more mature and flexible	12798	4	3383	3
PA_3	Mengembangkan sumber alternative	16914	5	3200	4
PA_1	Effective planning of patrol unit allocation	5994	4	2869	5
PA_6	Improving budget usage efficiency and evaluation	7740	4	1935	6
PA_5	Data driven and urgency based budget proposal	15744	4	1499	7

Source: Author.

This methodology was used to analyse risks and mitigation strategies, structured within a HOR corridor model combined with the Delphi method to generate logistics risk mitigation strategies for the base. The methodological approach in this study adopted an integrated framework encompassing the identification of risk factors, the determination of actual risk levels, and the formulation of risk mitigation strategies. Implementation is carried out through a combination of the Delphi and House of Risk (HOR) methods, whereby each stage of the process consistently adheres to the fundamental principles of HOR. The integration of Delphi and HOR has proven to demonstrate synergistic compatibility, enabling the two methods to complement one another and reinforce the validity and reliability of the research findings. This study offers innovation through an in-depth elaboration of a number of significant risk factors, namely: base facility factors, external environmental factors covering economic, security, political, and environmental aspects, and supporting infrastructure factors. The comprehensive integration of these three factors as risk variables analysed holistically constitutes a novelty in the context of this research, thereby providing a broader and deeper perspective compared to previous studies. The application of specific risk and mitigation theories -namely military base logistics- can be adapted and applied within complex and dynamic environments.

Furthermore, this research makes a practical contribution by identifying the specific risk factors faced by bases in logistical matters; this analysis is undoubtedly invaluable as a basis for decision-making, providing an understanding of the current challenges on the ground. It yields concrete and measurable mitigation strategies based on in-depth risk analysis. These strategies can be directly implemented by base logistics personnel to reduce the impact of risks, thereby enhancing logistical readiness, improving the supply chain, and contributing to increased operational efficiency of KRI vessels in border regions.

8. Implication.

Theoretical contribution: this study presents a model for the development of risk theory by integrating the Delphi-HOR method within the context of base logistics. This integration provides a comprehensive approach to identifying, analysing and mitigating risks. This study also explains the risk factors in base logistics, validated through Delphi expert consensus, thereby strengthening the theoretical foundation of military logistics, particularly in border regions.

Practical and managerial contributions: this study contributes to improving the operational efficiency of the Indonesian Navy (KRI) by providing analysis and mitigation of base logistics. This study helps improve base logistics readiness by identifying areas requiring improvement and providing recommendations for mitigation strategies.

Conclusions.

Through a systematic methodological approach, this study adopted the Delphi method, conducted in four rounds, to identify risk factors relevant to base logistics. The results of the Delphi analysis revealed 13 risk sub-factors clustered into three main factors: base facilities, the environment, and infrastructure. Furthermore, the mitigation strategy analysis resulted in the identification of five significant risk agents, as well as seven preventive action strategies. The calculated results yielded an Effectiveness to Difficulty Ratio of Action (ETD) ranging from 1499 to 3936. The ranking list of mitigation strategies includes: first place is data- and urgency-based budget proposals; second place is enhanced cooperation among stakeholders; third place is the development of alternative sources; and so on. The mitigation strategy of data- and urgency-based budget proposals emerged with the highest score as the most effective strategy to implement under the most difficult conditions.

This study still has several limitations that could be addressed in future research. Firstly, although this study identified various key factors influencing base logistics, a framework needs to be developed by analysing both tangible and intangible risks as a topic for future research.

Secondly, the discussion could incorporate cost-benefit analysis to provide a more comprehensive assessment of each proposed mitigation strategy.

This analysis will assist decision-makers in selecting strategies that are not only effective in reducing risk but also economically efficient. Thirdly, future research could include a discussion of inter-base logistics in establishing supply chains to maximise their effectiveness.

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