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Research Article

Risk Mitigation Strategy for Coal Transshipment

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A B S T R A C T

Coal transshipment necessitates efficient and prompt execution, devoid of any delays or work-related accidents. Numerous events during the transshipment process have the potential to disrupt operations and pose substantial risks. This research aims to examine the risks associated with coal transshipment by leveraging ISO 31000:2018 as the risk analysis framework. Additionally, it seeks to prioritize risk mitigation strategies employing the Techniques for Other Preferences by Similarity to Ideal Solutions (TOPSIS) methodology. Data collection for this study involved surveys and expert discussions to comprehensively analyze all risks by ISO 31000:2018 guidelines. The findings were then visualized through the use of a fishbone diagram, which facilitated the identification and understanding of the generated risks. The analysis revealed several threats that could impact the coal transshipment process. These major threats include natural disasters, equipment failures, shipping accidents, health risks for workers, fire hazards, operational delays, inefficient loading and unloading processes, and transportation accidents. The proposed mitigation strategies such as designing SOPs, developing emergency response plans, implementing safety measures, providing training, conducting risk assessments, and ensuring equipment maintenance, are academically supported and practical in their application. However, challenges such as financial constraints, resistance to change, and the dynamic nature of the process need to be overcome for effective implementation. Organizations can enhance safety and operational efficiency in coal transshipment by carefully managing resources, engaging stakeholders, and continuously evaluating and improving strategies. Overall, the proposed strategies offer a feasible and proactive means to mitigate threats and promote a safer and more efficient transshipment process.

INTRODUCTION

Transshipment is defined as the act of transferring cargo from a designated point of rest on a pier or lighter to be stored onboard a vessel according to the Decree of the Ministry of Transportation, as stipulated in Law (UU) No. 21/1992, and subsequently amended by Law (UU) No. 14/2002, Chapter I. This process entails the utilization of various heavy equipment, including bulldozers, wheel loaders, landing craft tanks (LCT), mother vessels (MV), barges, and floating cranes. Additionally, a team of skilled personnel is involved, encompassing operators, moorings personnel, forepersons, and surveyors. It is crucial to prioritize the maintenance of all equipment and ensure that the crew possesses the necessary proficiency to meet established standards. By doing so, potential obstacles or work-related accidents during the transshipment process can be effectively minimized. For an illustrative example of transshipment, please refer to Figure 1.

Figure 1. Coal Transshipment Process

The holding company operates within the Banjarmasin City region, specializing in the provision of bulk coal transshipment services. The company maintains a fleet consisting of 30

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bulldozers, 12 wheel loaders, 22 pairs of tugboats and barges, as well as ten floating cranes, which serve as the primary heavy equipment required for the execution of operational activities. Each transshipment project typically spans a duration of approximately seven days, involving an average cargo volume ranging from 50,000 to 80,000 metric tons (MT). The company has set a daily loading rate of 10,000 MT. The fuel consumption (diesel) per project amounts to approximately 2,500 to 3,000 liters on a daily basis. Notably, the company achieved coal transshipment volumes ranging from 7-12 Million MT in the years 2020, 2021, and 2022. The company consistently endeavors to augment its total production each year by delivering exceptional services to customers, ultimately maximizing profitability. However, amidst the company's notable achievements, various obstacles, particularly associated with transshipment risks, must be contended with.

During the transshipment procedure, numerous incidents gave rise to disruptions that present inherent risks to the transshipment process. These disturbances and potential threats engendered significant delays in transshipment activities, adversely impacting the schedule of the shipper. According to estimations provided by the Indonesian Coal Mining Association, shipment delays result in substantial financial losses for the shipper, ranging from approximately 250 million to 1 billion Rupiah on a daily basis. Consequently, it becomes imperative to expedite the transshipment process in accordance with the predetermined targets and agreed-upon schedule with the shipper. It is incumbent upon the company to ensure that transshipment operations are executed meticulously, adhering to established protocols, devoid of any impediments or untoward incidents.

The current absence of a standardized risk management system within holding companies represents a notable deficiency. The lack of preventive measures or risk mitigation strategies could have severe repercussions for the company. Notably, the company frequently faces threats such as damage to heavy equipment during the transshipment process, occurrences of minor or major accidents involving the crew, delays in the timely arrival of barges, incidents of crane failures, and substantial deformation of the mother vessel or barge. In light of the aforementioned risks and potential losses, it becomes imperative to establish an effective risk management system to govern the company's operational activities. Thus, the primary objective of this study is to comprehensively identify and analyze the risks at hand, subsequently devising appropriate mitigation strategies aimed at minimizing the adverse impact of these hazards.

This study adopts the Risk Management ISO 31000:2018 as the fundamental framework for designing a comprehensive risk management system for the company. ISO 31000:2018 represents the most up-to-date risk management standard developed by the International Organization for Standardization (ISO). According to ISO 31000, risk management encompasses a collection of components that establish the basis and organizational structure for the design, implementation, monitoring, review, and continual enhancement of risk management practices across the entire organization [1].

ISO 31000:2018 is structured into three overarching categories, each serving a distinct purpose [1]. The first category encompasses Scope, Context, and Criteria, providing a foundation for the risk management process. It involves defining the scope of risk management, understanding the organizational context in which it operates, and establishing the criteria against which risks will be evaluated.

The second category, Risk Assessment, comprises three key components: Risk Identification, Risk Analysis, and Risk Evaluation. Risk Identification involves systematically identifying and documenting potential risks that may affect the organization. Risk Analysis entails analyzing and understanding the nature, likelihood, and potential impact of identified risks. Risk Evaluation involves comparing the assessed risks against predetermined criteria to determine their significance and prioritize them accordingly.

The third category, Risk Treatment, addresses the development and implementation of risk response strategies. This stage involves selecting and implementing appropriate measures to mitigate, transfer, or accept the identified risks. Risk Treatment ensures that proactive actions are taken to manage risks effectively and reduce their potential impact.

Throughout the entire risk management process, it is essential to maintain accurate documentation in the form of records and reporting. This documentation serves as a reference for future assessments and facilitates communication and transparency regarding risk-related matters. Additionally, continuous monitoring and review are integral components of risk management, allowing for the ongoing evaluation of the effectiveness of risk mitigation measures and the identification of opportunities for improvement.

For a visual representation of these categories and their interconnections, please refer to Figure 2. ISO 31000 stands out from previous standards by not only outlining the risk management process but also emphasizing the importance of three key concepts and their interrelationships. These concepts include Scope, Context, and Criteria; Risk Assessment; and Risk Treatment. This comprehensive approach distinguishes ISO 31000 and showcases its advancement in the field of risk management.

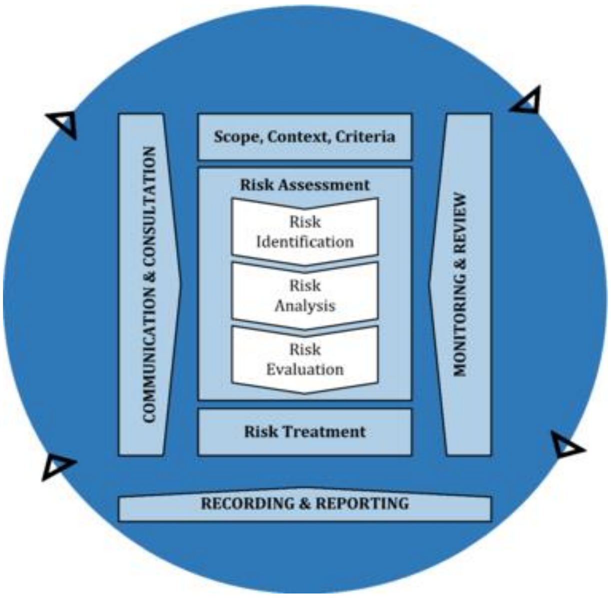

Figure 2. ISO 31000:2018 Process [1]

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ISO 31000's comprehensive coverage of these three concepts and the inclusion of organizational arrangements contribute to its significant influence on how risk is defined, assessed, and treated. The standard sets a benchmark for risk management practices, guiding organizations in adopting a systematic and holistic approach to risk management. ISO 31000 serves as a valuable resource for organizations in enhancing their understanding and management of risk across various domains and industries [2].

The latest version of ISO 31000 offers a comprehensive risk management system that provides a detailed methodology. This methodology places greater emphasis on strategic design, goal attainment, and informed decision-making. As a result, ISO 31000 serves as a solid foundation for designing risk management systems within companies. ISO 31000 recognizes the importance of considering the internal and external context of an organization when designing its risk management system. By acknowledging these contextual factors, organizations can tailor their risk management approach to suit their unique circumstances and requirements [3].

Numerous studies conducted by previous researchers have leveraged ISO 31000:2018 as a framework for designing risk management systems in various industries. One such study focused on the use of ISO 31000:2018 in the context of heavy machinery vehicles to prevent disruptions in company operations and mitigate potential profit reductions. The research identified and assessed 20 risks associated with handling heavy machinery, with a particular focus on prioritizing strategies for managing undercarriage parts. As a risk mitigation measure, the study recommended the adoption of a vehicle rental approach in instances where damage was detected in the company's own machinery [4]. Similarly, another study implemented ISO 31000:2018 in the palm oil industry to design machine maintenance programs. The research applied the principles and guidelines outlined in ISO 31000:2018 to develop effective maintenance strategies for machinery used in palm oil production [5].

ISO 31000:2018 is indeed a suitable risk management standard for consulting service companies. One research study utilized variables such as governance, business processes, structure, technology, and people as the foundation for designing a risk mitigation strategy within consulting service firms [6]. Its approaches allow organizations to assess and address risks across multiple dimensions, ensuring a comprehensive risk management framework.

Another study combined Bayesian Networks with ISO 31000:2018 in the context of maritime oil spills. The research successfully integrated Bayesian Networks with the principles of ISO 31000:2018, enabling decision-makers to make informed decisions in situations where risks are complex and data may be limited. This integration provided a flexible approach to incorporate various sources of probabilistic knowledge, enhancing the overall risk management process [7]. Additionally, research has been conducted to develop a risk analysis framework specifically tailored to shellfish aquaculture. This study utilized ISO 31000 as the basis for designing a comprehensive risk analysis tool to aid decision-makers in the industry. The framework enabled the sector to advance strategies for risk elimination or avoidance, promoting more effective risk management practices within the shellfish aquaculture domain [8].

Integrated approaches combining ISO 9001:2015 and ISO 31000:2018 have been utilized in several studies to develop risk-based thinking and enhance risk management practices. Here are examples of studies that incorporate these standards:

- A field study focused on manufacturing small- and medium-sized enterprises (SMEs) under ISO 9001:2015 and the application of risk-based thinking. The research aimed to prioritize risk sources and analyze how these organizations intended to manage risks and their associated effects [9].
- A study conducted in a transport company implemented a quality management system (QMS) to design risk management within their complex business processes. The research developed an algorithm based on ISO 31000:2018 to detect varying levels of risk complexity. The findings demonstrated that the risk-oriented approach in the organization's QMS emphasized management decisions and the identification of potential events and consequences [10].
- Similar research in transport enterprises integrated QMS with risk management in service quality, occupational health and safety, and environmental protection [11].

To visualize the results of risk analysis in ISO 31000:2018, the fishbone diagram has been commonly employed. Fishbone diagrams help to identify potential risk factors that contribute to overall problems. The visual representation assists in determining alternative strategic plans for risk mitigation [12]. The mitigation strategies can be prioritized using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method. The formulation of mitigation strategies involves operational decisions that the company will implement, impacting its overall effectiveness [13].

The TOPSIS method has been used in various studies to select and prioritize strategies. For instance, it has been employed to address inventory accumulation in manufacturing companies [14], design safety data management system strategies based on company policies in technology companies [15], evaluate multiple risks in urban areas near rivers [16], develop system maintenance strategies [17], and identify and prioritize risk mitigation strategies in river dam construction projects [18]. Given the described problems, this study analyze risks in the coal transshipment process using ISO 31000:2018 and employ the TOPSIS method to prioritize alternative risk mitigation strategies.

METHOD

Figure 3 provides an overview of the research framework. The initial stage of this study involved a preliminary study. Data were gathered through observations, interviews, and the administration of questionnaires to two key respondents: the Operational Department Head (Expert 1) and the General Manager (Expert 2). Expert 1 possesses extensive professional experience of over 15 years in the field of transshipment coal. Expert 1 has acquired a comprehensive knowledge of the coal industry, encompassing the processes and logistics associated with coal transportation and handling. Expert 1's expertise encompasses cargo handling,

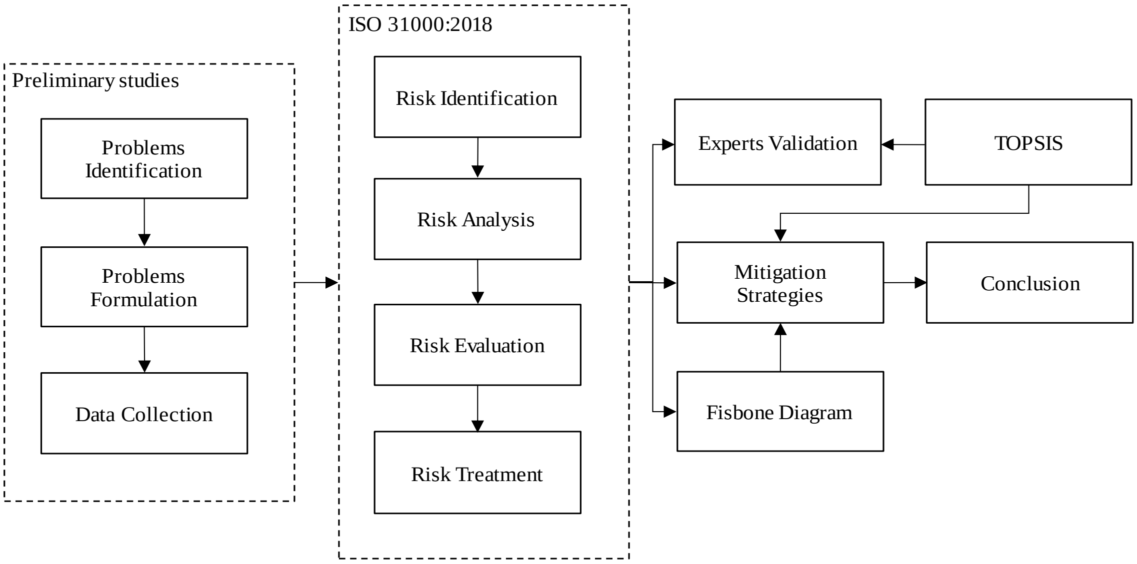

Figure 3. Conceptual Research Framework

shipping, logistics, and specialized knowledge of coal quality, specifications, and pricing. On the other hand, Expert 2, as General Manager, brings over 10 years of diverse professional experience in shipping, coal, and business management. His expertise lies in personnel and operations management, along with a profound understanding of the shipping and coal industries. Expert 2 has relevant experience in areas such as sales and marketing, finance, and risk management, and possesses a wide network of industry contacts.

To gain insight into the company's business processes, personnel involved, and the risks associated with coal transshipment, interviews, and observations were conducted. The first questionnaire employed was the Risk Analysis Questionnaire, which aimed to identify existing threats and determine the levels of Consequence, Likelihood, Risk Priority Number, and Risk Level. Subsequently, the Mitigation Strategies questionnaire was utilized to prioritize strategies for mitigating risks in coal transshipment.

The subsequent stage involves data processing, which commences with the identification of risks following the guidelines outlined in ISO 31000:2018. The data utilized in this process is derived from the questionnaires completed by the aforementioned respondents during the risk identification stage, and it extends to the final phase of determining risk mitigation strategies using the TOPSIS method. Table 1 presents the reference values for the Consequences Level, while Table 2 provides the reference values for Likelihood.

Risk Management based on ISO 31000:2018

Data from the Risk Analysis Questionnaire is processed based on Risk Management ISO 31000:2018 [1].

Risk Identification

The primary objective of risk identification is to identify, analyze, and describe the risks that impede the company from attaining its objectives. It is crucial to gather relevant, accurate, and current information to ensure effective risk identification. The company must ascertain the sources of these threats and determine whether they are under control. It is important to recognize that there may be multiple potential outcomes that can give rise to various tangible or intangible threats. By considering these factors, the company can comprehensively assess the risks it faces and develop appropriate risk management strategies to mitigate their impact.

Risk Analysis

Risk analysis aims to gain a comprehensive understanding of the nature of risk, including its characteristics and the level of risk it presents. This analysis involves a thorough examination of various aspects, such as uncertainty, risk sources, consequences, likelihood, events, scenarios, controls, and their effectiveness. It is important to note that a particular threat can stem from multiple causes and be influenced by various factors that impact operational activities. By conducting a detailed risk analysis, organizations can better assess the potential risks they face, identify their underlying causes and influences, and determine the most appropriate measures to manage and mitigate those risks effectively.

Risk Evaluation

The primary objective of risk evaluation is to provide support for strategic decision-making processes. This evaluation entails comparing the results obtained from the risk analysis with predefined risk criteria and determining whether any further actions are required. These decisions can encompass a range of options, such as choosing not to take any immediate action, considering various risk management alternatives, or even modifying existing procedures and practices. By conducting a thorough risk evaluation, organizations can make informed decisions about how to address and manage risks, taking into account their potential impact and aligning them with their overall strategic objectives.

Risk Treatment

The selection of the most suitable risk management option involves balancing potential benefits with cost, effort, and time considerations. It should align with the company's objectives,

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Table 1. Consequences Level [1]

Consequence Level	Non-Financial Impact			Financial Impact	
	Labour Relations	**Health & Safety**	**Regulations**	**Potential loss (million Rupiah)**	***Unscheduled Stoppage*** **(days)**
1 *Significant*	Operational stopped	Fatal accident to death	Operational ban	> 100	*days stoppage* > 7
2 *Major*	Operational slowed down	Treatment > 20 days	Operational temporary ban	70 < *Loss* < 100	7 < *days stoppage* < 3
3 *Moderate*	Mediation with third parties	Treatment < 20 days	Written warning with the penalty	40 < *Loss* < 70	3 < *days stoppage* < 2
4 *Minor*	Complaints from activity	Minor injury	Written warning without penalty	10 < *Loss* < 40	2 < *days stoppage* < 1
5 *In-Significant*	Isolate dissatisfaction	First aid	Informal verbal warning	< 10	*stoppage* = 1 *day*

Table 2. Likelihood [1]

Likelihood	**Probability**	***Health Events Only***	**Frequency**
A Almost certain	Often occur Probability 90%	1 case/10 *person-years*	Many times per annum, continuous
B Most likely	Occur easily Probability 50%	1 case/100 *person-years*	Once or twice per annum
C There is a possibility	Occur and has occurred elsewhere Probability 10%	1 case/1,000 *person-years*	Once in 5 years
D Almost impossible	Not yet, but it will happen Probability 1%	1 case/10,000 *person-years*	Once in 10 years
E Impossible	May occur under exceptional circumstances Probability 0,01%	1 case/100,000 *person-years*	Impossible

risk criteria, and available resources. Mitigation strategies include avoiding, controlling, separating, transferring, or accepting the risk.

Determine the Root of the Problem Using the Fishbone Diagram

A fishbone diagram is a visual tool used to depict root causes and the outcomes of risk identification. It aids in developing strategies for risk mitigation. In a study conducted on machine breakdown issues in a textile company, the fishbone diagram effectively identified the primary cause. The study demonstrated that the fishbone diagram can pinpoint prevailing issues and facilitate the determination of problem-solving strategies [19].

Determine Priority Strategies Using TOPSIS

Using analysis results from ISO 31000:2018, TOPSIS will prioritize the mitigation strategies to solve problems in transshipment. The procedure of TOPSIS is described through several stages [20]:

Determination of Alternative Mitigation Strategies

Alternative strategies are determined based on the Risk Priority Number (RPN), which is obtained from the Risk Management ISO 31000:2018 guidelines. These strategies are identified through literature studies, interviews, and expert discussions. The outcome of this process generates several alternatives that align with the company's internal business and policies.

Create a normalized decision matrix and a weighted normalized decision matrix

In this step, the alternative strategies are normalized by dividing the square root of the measured performance attribute value. This normalization process is followed by converting the values into weighted normalized scores, taking into account the predetermined weight of each criterion. The criteria utilized in this assessment are customer satisfaction [21], health & safety [22], cost [14], and internal business [23].

Calculating the distances of positive and negative ideal solutions

In this step, the selection process involves identifying the alternative with the smallest distance from the positive ideal solution and the largest distance from the negative ideal solution [24]. However, it is important to note that the alternative with the smallest distance from the positive ideal solution may not necessarily have the largest distance from the negative ideal solution. This is because the TOPSIS method considers both the distances from the positive and negative ideal solutions simultaneously, taking into account the overall evaluation of the alternatives.

Ranking of Alternative Mitigation Strategies

In the final stage of the TOPSIS method, the alternatives are ranked to determine the most suitable mitigation strategies. The alternatives with the highest values are assigned the top ranks, while the lower-ranked alternatives follow accordingly. This ranking of alternatives enables the company to focus on and prioritize the strategies based on their associated benefits. By considering the rankings, the company can make informed decisions about which mitigation strategies to prioritize and allocate resources accordingly.

RESULTS AND DISCUSSION

The risk management design was based on the fundamental concepts outlined in ISO 31000:2018. It incorporated four key stages: Risk Identification, Risk Analysis, Risk Evaluation, and Risk Treatment. By following this framework, the organization can systematically identify, analyze, evaluate, and address risks in a structured and effective manner, aligning with the principles and guidelines set forth in ISO 31000:2018.

Risk Management Based on ISO 31000:2018

Risk Identification

Based on discussions and interviews with experts, they determined 22 risks in coal transshipment. Table 3 shows the list of threats.

Risk Analysis

Risk analysis is carried out based on Risk Management ISO 31000:2018 to determine the impact of risk (consequences level) and the likelihood of the risk occurring (Likelihood). All these risks determined the RPN value and Risk Level. Furthermore, all these risks are mapped into a Risk Mapping based on the RPN value. Table 4 show the results of the risk analysis. Then Figure 4 describe the Risk Mapping based on the Risk Analysis assessment.

During the transshipment process, all personnel was divided into three shifts (8 hours per shift) per day. In the first and second shifts (morning to afternoon), all personnel work directly under exposure to sunlight and get hotter because of the evaporation of heat generated by coal. Then the scattering of flying coal dust will interfere with the operator's breathing. Conversely, if the weather is terrible, such as rain, the work must be stopped to prevent rainwater from entering the ship's hold or causing work accidents. The effects of bad weather will increase the project's duration and the risk of accidents, such as a wet and slippery work area. Not to mention the crashing waves that made the barge and mother vessel sway and collide quite hard. In this case, the mooring ropes must be paid full attention to because if the ties are too tight, then the possibility of breaking will be higher, and if they are too loose, then there is a possibility that the ties will loosen and the waves will wash away the barge.

The equipment quality also significantly affects the duration of the transshipment. Often this equipment suffers unscheduled breakdown during operation, whether it is damage to the bulldozer, wheel loader, or floating crane. If the wheel loader or bulldozer is damaged, the work will continue even though it

Table 3. Risk Identification and Risk Analysis

Risk Identification	Risk Code	Risk Analysis			
		Consequences	Likelihood	RPN	Level of Risk
Unhealthy work environment (e.g., hot sunlight, thick dust, dry)	R 1	5	A	15	Medium
Natural disasters (e.g., hurricanes, waves, floods)	R 2	1	A	1	Significant
Hazard in the crane maneuver area	R 3	3	D	17	Medium
Insufficient safety measures	R 4	3	C	13	Medium
Equipment Failure (e.g., heavy equipment, crane, grab)	R 5	2	B	5	Significant
Shipping accidents or collisions	R 6	2	C	8	High
Health Risks and occupational hazards for Workers	R 7	2	C	8	High
Technological disruptions or failures impacting operations	R 8	3	C	13	Medium
Drowning personnel or equipment	R 9	2	E	16	Medium
Fire hazards during coal handling	R 10	1	E	11	High
Operational delays	R 11	2	C	8	High
Port congestion and delays	R 12	4	B	14	Medium
Supply chain disruptions (e.g., fuel, equipment)	R 13	4	D	21	Low
Environmental pollution and emissions (e.g., fuel or coal spill)	R 14	2	E	16	Medium
Inadequate training and skill gaps	R 15	4	D	21	Low
Inaccurate documentation and paperwork	R 16	4	C	18	Low
Security breaches and theft	R 17	3	D	17	Medium
Inefficient loading and unloading processes	R 18	2	B	5	Significant
Labor shortages or strikes affecting operations	R 19	2	E	16	Medium
Lack of contingency plans for emergencies or unforeseen events	R 20	3	E	20	Low
Regulatory compliance issues	R 21	3	D	17	Medium
Transportation accidents during the process	R 22	2	D	12	High

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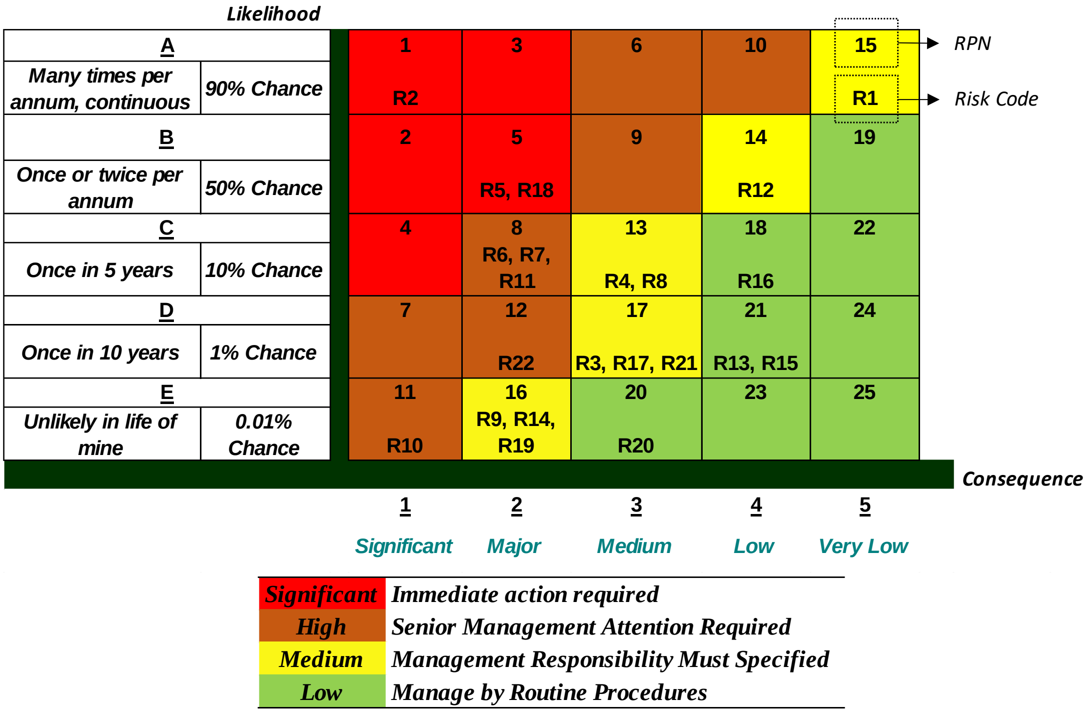

Figure 4. Risk Mapping Based on Risk Analysis

will increase fuel consumption and lower loading rates. However, the transshipment process must be stopped if the floating crane is damaged. If this damage cannot be repaired on-site, then the floating crane needs to be replaced, and this will take much time and increase the duration of the transshipment process not to mention the costs.

Supporting equipment such as mooring ropes, chains, and fuel quality also affect the duration of the transshipment process. Mooring ropes have many types and functions based on their role. The strength of the mooring rope ties must also be considered according to weather and wave conditions. The quality chain must also be in good condition; if there is rust or cracks, it should be replaced or repaired because there is a possibility that the chain will break when lifting heavy equipment or cranes. A broken chain is one of the frequent accidents because it often escapes the attention of personnel. The risk of chain breaking is quite severe, such as befalling personnel or heavy equipment falling into the sea. Lastly, fuel quality also must meet the standards set by the government. Heavy equipment such as bulldozers and wheel loaders are susceptible to fuel quality. The machine system of heavy equipment will be damaged if there is dirt in the fuel. Therefore, before using the fuel, it is necessary to filter it before inserting it into the heavy equipment's fuel cylinder. The process of fuel filling also needs to be considered to prevent fuel from spilling onto the barge floor or MV. It is dangerous because it will cause a cargo fire or contaminate the oceans. If fuel or oil spills into the sea, the company will be penalized by the government, and it is necessary to clean or sterilize the sea.

The threat of inefficient loading and unloading processes in the coal transshipment process can have significant implications for operational efficiency, cost-effectiveness, and safety. This threat is caused by various factors, including inadequate equipment or infrastructure, a lack of standardized procedures, and inefficient coordination and communication between stakeholders. The impact of inefficient loading and unloading processes includes operational delays, increased costs, and safety risks. These inefficiencies can lead to financial losses, reputational damage, missed delivery deadlines, and potential accidents or injuries. The severity of the threat depends on the extent and frequency of inefficiencies, with consistently inefficient processes posing a higher risk.

The threat of inadequate training and skill gaps in the coal transshipment process poses significant risks to operational efficiency, safety, and overall performance. This threat arises from causes such as insufficient training programs, limited resources allocated for training, and high turnover rates. The impact of inadequate training and skill gaps includes decreased productivity, safety risks, and increased errors and delays. These consequences can range in severity from moderate to high, depending on the criticality of tasks, the extent of skill gaps, and the frequency of errors or safety incidents. Inadequate training and skill gaps present substantial risks, leading to operational inefficiencies, safety incidents, and potential financial losses.

Risk Evaluation

It is necessary to evaluate by analyzing the impact, causes, and action on all threats with a "Significant" and "High" level of risk as shown in Table 4. These risks will be analyzed in more detail regarding the impacts, causes, and actions. Based on the analysis results, the highest risks are mostly difficult to control, such as weather/waves, unscheduled breakdowns, and work personnel accidents. The best treatment to deal with this problem is to take preventive measures before this risk occurs. Therefore, companies must regularly update weather reports and carry out transshipment based on the reports. Then it is necessary to pay attention to the health of the heavy equipment used so that there is no damage during work. It is also essential to provide work safety briefings and training to all personnel to improve their skills.

Table 4. Significant and High Levels of Risks

Risk Code	Level of Risk	Impact	Causes	Action to Minimize
R 2	Signi-ficant	• Disruption of operations • Damage to infrastructure and equipment • Safety hazards	• Geographic location in disaster-prone areas • Unpredictable weather patterns	• Develop a comprehensive disaster preparedness plan with clear evacuation procedures and communication protocols. • Regularly monitor weather conditions and have early warning systems in place. • Establish contingency plans to secure equipment and minimize damage during natural disasters.
R 5	Signi-ficant	• Operational delays • Damage to cargo • Safety hazards	• Lack of maintenance • Mechanical failures • Aging equipment	• Establish a preventive maintenance program to regularly inspect and maintain equipment. • Implement a system for reporting and addressing equipment issues promptly. • Have backup equipment or contingency plans in place to minimize disruptions.
R 6	High	• Damage to vessels • Cargo loss & safety risks • Environmental pollution	• Human error • Navigational challenges • Inadequate communication	• Implement strict navigation and collision avoidance protocols. • Install advanced monitoring and warning systems to prevent accidents. • Provide proper training and certifications for ship captains and crews.
R 7	High	• Work-related illnesses • Injuries • Long-term health implications	• Exposure to hazardous substance • Inadequate safety measures • Lack of protective equipment	• Conduct regular health and safety assessments to identify and address potential hazards. • Provide proper training and personal protective equipment for workers. • Implement health monitoring programs to detect and occupational health risks
R 10	High	• Property damage • Injuries • Environmental pollution • Operational shutdowns	• Improper handling of flammable materials • Electrical faults • Inadequate fire prevention measures	• Implement fire prevention measures, such as proper storage and handling of flammable materials. • Install fire detection and suppression systems in critical areas. • Conduct regular fire drills and train personnel on fire safety procedures.
R 11	High	• Disruption of schedules • Financial loses • Customer dissatisfaction	• Inefficient processes • Inadequate resources • Lack of contingency plans	• Implement efficient scheduling and coordination systems to minimize delays. • Improve communication channels between different stakeholders involved in the process. • Conduct regular assessments to identify bottlenecks and areas for process optimization.
R 18	Signi-ficant	• Delays in cargo handling • Increased costs • Potential damage to goods	• Inadequate equipment • Lack of coordination • Improper cargo handling techniques	• Optimize workflow and resource allocation to improve loading and unloading efficiency. • Invest in equipment and technologies that enhance productivity and streamline operations. • Provide adequate training and supervision to personnel involved in the loading and unloading processes.
R 22	High	• Property damage • Injuries • Environmental hazards • Operational disruptions	• Accidents • Waves • Human errors	• Implement strict safety protocols for transportation activities, including proper vehicle maintenance and driver training. • Monitor driver performance and enforce safe driving practices. • Conduct regular safety inspections of vehicles and ensure compliance with transportation regulations.

Risk Treatment

Based on the risk evaluation, it is necessary to design strategies to mitigate existing risks. Experts developed this strategy based on field activities and company policies. Experts decided that the best strategy for dealing with risks is to take preventive measures before an accident occurs. Table 5 shows the details of these strategies.

Determine the Root of the Problem Using the Fishbone Diagram

Figure 5 will describe a fishbone diagram based on the results of risk identification using ISO 31000:2018.

The fishbone diagram will categorize them into several categories.

Man

The primary determinant of this particular category is the deficiency in personnel's skillset. This dearth of skills may result in various associated hazards, encompassing both minor and major accidents, as well as delays in the arrival of personnel and cargo.

Machine

In this context, the term "machine" refers to substantial machinery utilized in transshipment activities, including

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bulldozers, wheel loaders, floating cranes, grabs, and barges. Any form of damage, whether minor or severe, inflicted upon this heavy equipment will profoundly influence the transshipment timetable.

Material

Materials encompass equipment and supporting apparatus utilized in transshipment operations, encompassing items such as wire ropes, mooring lines, fuel oil, and various others. Prior to their utilization in the process, this equipment must adhere to established standards.

Method

This category elucidates the risks linked to transshipment procedures. The incapacity of personnel to execute transshipment tasks is expected to give rise to risks. The ensuing consequences are likely to be substantial, encompassing heavy equipment damage, delays, and potential halts in transshipment operations.

Environment

Controlling this category presents challenges due to its association with uncontrollable elements, such as weather conditions and ocean waves. In the event of such risks, personnel are compelled to halt transshipment activities. Furthermore, adverse weather conditions adversely affect the efficiency of transshipment by rendering the work area wet and slippery. Additionally, the quality of coal is compromised as it becomes water-laden.

Table 5. Risk Mitigation Strategies

Code	Risk Mitigation Strategy
S1	Design Standard Operating Procedures (SOP) based on ISO 9001:2015 as a guideline for transshipment.
S2	Develop a comprehensive emergency response plan that includes evacuation procedures, communication protocols, and coordination with relevant authorities. Conduct drills and exercises regularly to test the effectiveness of the plan and ensure preparedness for emergencies.
S3	Create a Transhipment Standard Check Sheet covering the ship's inclination level, gauge level, buoyancy standard, strapping standard, and wave height.
S4	Provide complete Personal Protective Equipment (PPE) and first aid kits for all personnel involved in transshipment.
S5	Implement a robust risk management framework that includes regular risk assessments, risk mitigation action plans, and periodic review and update of risk registers. This ensures a proactive approach to identifying and managing risks throughout the transshipment process.
S6	Implement a robust training and certification program for all personnel involved in the transshipment process, including cargo handlers, crane operators, and maintenance staff. Regularly update and refresh training modules to ensure adherence to best practices and industry standards.
S7	Design a backlog and overhaul maintenance scheduling system for all equipment to ensure their proper maintenance.
S8	Establish a system for real-time weather monitoring and forecasting specific to the transshipment location. This will enable proactive decision-making regarding potential weather-related risks and facilitate appropriate preventive measures.
S9	Conduct regular safety audits and inspections to assess the effectiveness of the implemented mitigation strategies and identify areas for improvement
S10	Maintain an inventory of main spare parts for all equipment to minimize downtime and facilitate prompt repairs.

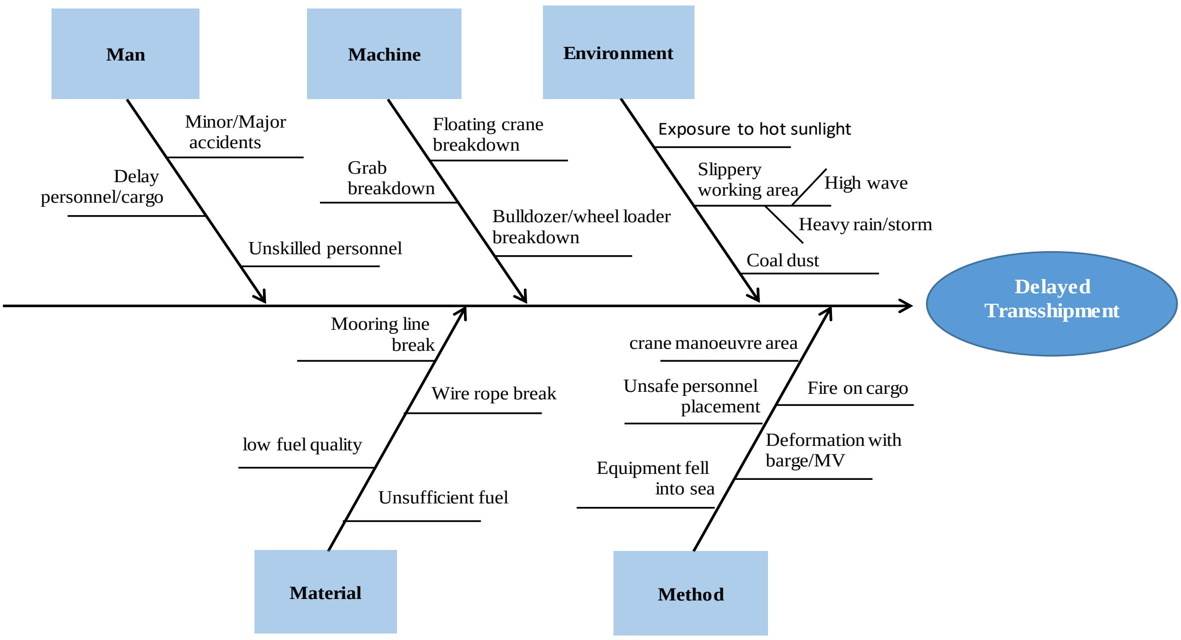

Figure 5. Fishbone Diagram

Determine Priority Strategies Using TOPSIS

In order to prioritize the mitigation strategies, it is essential to assign priority based on specific criteria. The criteria used are Customer Satisfaction (C1), Health & Safety (C2), Cost (C3), and Internal Business (C4) in sequential order. Preference weights have been determined through expert agreement, with respective weights of 0.3125, 0.25, 0.25, and 0.1875. Table 6 presents the data processing utilizing the TOPSIS method.

To implement the proposed mitigation strategies effectively, organizations can draw on previous research and studies conducted in relevant fields. Some discussions that highlight the importance of aligning with ISO 9001:2015 and developing comprehensive emergency response plans, respectively [25, 26]. They provide insights into the structure and components that should be considered during the implementation phase. A field study focused on manufacturing small- and medium-sized enterprises (SMEs) offers valuable perspectives on risk-based decision support systems, which can inform the development of the Transshipment Standard Check Sheet (strategy 3). This is also supported by research conducted at Tanjung Priok Port Container Terminal [27].

Training and certification programs (strategy 6) can benefit from the competence-based approach discussed in maritime logistics skills and competences, ensuring that the training content and assessment methods align with industry standards and competency requirements [28]. Some research to optimize spare parts management in maritime sectors shed lights on effective spare parts management and maintenance scheduling, providing guidance on implementing strategy 7 [29][30]. Incorporating risk-based weather routing (strategy 8) can be informed by the methodology described in research regarding weather-routing system, which focuses on optimizing routes based on weather conditions to mitigate potential risks [31].

Safety audits of maritime operations offer valuable insights into auditing processes and can be used to design and conduct safety audits and inspections (strategy 9) [32]. The optimization of spare parts inventory systems for port machinery provides guidance on inventory management practices that can be applied to maintain an inventory of main spare parts (strategy 10) [30].

However, several challenges and limitations may arise during the implementation of these strategies. Financial constraints can pose obstacles, particularly for smaller organizations, requiring careful budgeting and prioritization. Resistance to change and lack of awareness among personnel may hinder the adoption and adherence to new procedures and practices. Limited resources and expertise can also impede the effectiveness of training and certification programs.

Furthermore, unintended consequences may arise from the implementation of these strategies. Increased workload and coordination efforts may be necessary to integrate the strategies into existing processes and systems. Conflicts with existing agreements, labor unions, or regulatory requirements can create challenges. Organizations must carefully manage these potential unintended consequences through effective communication, stakeholder involvement, and continuous monitoring and adaptation.

The proposed mitigation strategies can be implemented effectively by leveraging previous research and best practices. References in quality management systems, emergency response planning, risk-based decision support systems, training programs, spare parts management, weather routing, safety audits, and optimization of inventory systems provide valuable insights. However, challenges related to financial constraints, resistance to change, and potential unintended consequences should be carefully addressed. Feasibility studies should be conducted to assess the financial, operational, and organizational capacity to implement and sustain the strategies. Stakeholder engagement and effective communication are crucial in overcoming resistance to change and ensuring personnel awareness and buy-in.

To address financial constraints, organizations can explore cost-saving measures such as prioritizing high-impact strategies, seeking partnerships or grants, or implementing phased implementation plans. Building a safety culture and providing ongoing training and support can help overcome resistance to change and bridge skill gaps. Careful planning and coordination are essential to integrate the proposed strategies into existing processes and systems. Pilot testing and feedback from stakeholders can help identify and mitigate potential conflicts or disruptions. Continuous monitoring and evaluation should be conducted to assess the effectiveness of the strategies, identify areas for improvement, and adapt them accordingly.

While the proposed strategies aim to mitigate the identified threats, there may be unintended consequences. For instance, the implementation of new SOPs and safety measures may initially result in increased workload and adjustment challenges for personnel. It is important to provide adequate training, resources, and support during the transition period to minimize disruptions and ensure successful adoption. Additionally, the feasibility of implementing these strategies may vary depending on the specific context and resources available to each organization. Organizations should consider their unique circumstances, such as size, budget, and operational complexities, when determining the feasibility and prioritization of the strategies.

In conclusion, the proposed mitigation strategies can be implemented effectively by considering previous research, conducting feasibility studies, addressing financial constraints, and managing potential unintended consequences. Stakeholder engagement, ongoing training, and effective communication are essential elements for successful implementation. Organizations should tailor the strategies to their specific context, continuously monitor their effectiveness, and adapt them as necessary to improve safety and operational efficiency in the coal transshipment process.

CONCLUSION

In conclusion, the identified mitigation strategies provide a comprehensive approach to address the threats associated with the coal transshipment process. These strategies, including designing SOPs, developing emergency response plans, implementing safety measures, providing training, conducting risk assessments, and ensuring equipment maintenance, are

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Table 6. TOPSIS Data Processing

Preference Weight	**0.3125**	**0.25**	**0.25**	**0.1875**
Normalized Decision Matrix				
Alternatives	**C1**	**C2**	**C3**	**C4**
S1	0.183	0.393	0.182	0.338
S2	0.367	0.314	0.273	0.254
S3	0.367	0.314	0.182	0.338
S4	0.367	0.393	0.364	0.254
S5	0.183	0.393	0.273	0.423
S6	0.367	0.393	0.455	0.338
S7	0.458	0.157	0.455	0.423
S8	0.275	0.236	0.182	0.169
S9	0.275	0.314	0.364	0.338
S10	0.183	0.079	0.273	0.169
Rooted sum sq.	**10.909**	**12.728**	**11.000**	**11.832**

Weighted Normalized Decision Matrix								
Alternatives	**C1**	**C2**	**C3**	**C4**	***Si+***	***Si-***	***Ci***	***Rank***
S1	0.057	0.098	0.045	0.063	0.111	0.085	0.433	8
S2	0.115	0.079	0.068	0.048	0.065	0.087	0.570	4
S3	0.115	0.079	0.045	0.063	0.078	0.088	0.530	6
S4	0.115	0.098	0.091	0.048	0.048	0.109	0.692	2
S5	0.057	0.098	0.068	0.079	0.097	0.095	0.493	7
S6	0.115	0.098	0.114	0.063	0.033	0.123	0.790	1
S7	0.143	0.039	0.114	0.079	0.059	0.121	0.673	3
S8	0.086	0.059	0.045	0.032	0.108	0.049	0.310	9
S9	0.086	0.079	0.091	0.063	0.067	0.086	0.563	5
S10	0.057	0.020	0.068	0.032	0.134	0.023	0.145	10
Vj+	0.143	0.098	0.114	0.079				
Vj-	0.057	0.020	0.045	0.032				

academically supported and practical in their application. However, challenges such as financial constraints, resistance to change, and the dynamic nature of the process need to be overcome for effective implementation. By carefully managing resources, engaging stakeholders, and continuously evaluating and improving the strategies, organizations can enhance safety and operational efficiency in coal transshipment. Overall, the proposed strategies offer a feasible and proactive means to mitigate threats and promote a safer and more efficient transshipment process.

For further research, it can be developed based on Benefit, Cost, Opportunity, and Risk (BCOR) to identify risks. It is also possible to use Failure Modes and Effects Analysis (FMEA) to identify risks in a process [33]. Then the AHP-TOPSIS method as a multi-criteria assessment method to determine alternative strategies to be more accurate and stable.

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