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Research Article

Analyzing Supply Chain Risks Using the House of Risk Method: Evidence from the Salt Industry in Padang City

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ABSTRACT

Salt remains an important commodity for households and food-related businesses in Indonesia. In Padang City, the availability of salt can be affected when problems occur in raw material procurement, processing, or distribution. Such problems may also make daily activities more difficult for the actors in the chain. Although these risks are often encountered in practice, their priority in the local salt industry has not been systematically studied. This study applies the House of Risk (HOR) method to analyze supply chain risks in the salt industry of Padang City. The data were collected using questionnaires distributed to actors involved in procurement, processing, and distribution. These respondents were included because they handle the activities directly and understand the problems that appear in day-to-day operations. The analysis considers the severity of risk events, the occurrence of risk agents, and the relationship between risk events and their causes. These values were then used to calculate the Aggregate Risk Potential (ARP), which served as the basis for prioritizing risks. The findings show that risk exposure is mainly concentrated in procurement and production activities. This means that mitigation efforts should give more attention to these two stages. Preventive actions were then compared by looking at two practical considerations: how useful each action was expected to be and how difficult it would be to apply. The analysis shows that a small number of risk agents make a major contribution to the overall risk exposure. For this reason, these agents should be handled first. This order of action can help the actors reduce the most important risks without making the supply chain too rigid when conditions change.

Keywords: Supply chain risks, aggregate risk potential, HOR, cement industry

INTRODUCTION

Supply chains now operate across wider and more connected networks. This condition brings benefits, but it also makes companies more vulnerable to disruption. For this reason, risk management has become a necessary concern in supply chain management [1], [2], [3]. Risks that arise within a supply chain can affect both its effectiveness and efficiency. These risks may disrupt material flows, delay deliveries, and ultimately impede the growth and performance of organizations operations depend on interconnected supply networks [4]. As supply chains become increasingly complex and interdependent, the need for systematic and structured risk management approaches has become more critical. Consequently, risk management has attracted growing attention in both academic research and industrial practice. At the same time, [5] reviewed existing approaches to quantitative supply chain risk management by focusing on the definition of supply chain risk and related analytical concepts. A review of the literature discussing supply chain risk management was conducted by [1] and [2]. Specific discussions of supply chain risk management in various commodity sectors have also been widely conducted, for example, [6] in crumb rubber, [7] and [8] in palm oil, [9] in corn, and [10] in refined sugar. Discussion of supply chain management in salt commodities has been conducted by [11] and [12]. Previous studies demonstrate the growing importance of supply chain risk management across various commodities. However, most existing studies emphasize general frameworks or focus on large-scale agro-industrial contexts, while empirical risk prioritization at the city-level supply chain remains limited. In addition, structured decision-support approaches for systematically identifying and prioritizing risk mitigation actions are still rarely addressed. Previous studies on Indonesian food SMEs show that the use of Good Manufacturing Practices (GMP), lean manufacturing principles, and supporting information technologies can help improve process reliability and reduce operational vulnerabilities in production and distribution activities [13].

In Indonesia, salt is used by households and many food-related businesses. The national production figures also show how unstable this commodity can be. Records from the Directorate General of Sea Space Management at the Ministry of Marine Affairs and Fisheries show production of 2,502,891 tons in 2014. In 2015, production increased to 2,891,461 tons. One year later, the figure dropped sharply to 144,009 tons. Based on [14], the 2016 decline was related to La Niña because the dry season became wetter than normal. Another factor was the limited technology available to salt farmers. This large fluctuation indicates that salt production is highly sensitive to environmental conditions and operational limitations. Therefore, structured supply chain risk management is particularly important in this commodity.

Meanwhile, traditional industrial salt supply chains in China cannot match supply and demand very well due to demand uncertainty, which causes huge losses for salt-making companies and also affects the performance of the entire supply chain. Demand uncertainty that impacts supply chain performance is an essential issue for the industrial salt supply chain [11]. [15] provides insight into how supply chain risk management affects organizational performance. [6] propose supply chain management strategies in the crumb rubber industry. [8] provides a risk assessment model, and [7] provides risk mitigation analysis in the palm oil industry. [11] state that the traditional salt industry in China has a significant risk problem in terms of demand uncertainty, and the conventional mode of operation in the salt supply chain affects the performance of the entire supply chain. [12] state that the salt industry faces difficulties in meeting high demand due to the difficulty of predicting and meeting raw material needs and allocating products. In the context of Padang City, disruptions in salt supply can affect procurement, processing, and distribution activities simultaneously. Despite the strategic role of local salt producers, systematic identification of risk events, their underlying causes, and prioritized preventive actions has not been sufficiently addressed in existing studies. This condition highlights the need for a structured analytical approach to support risk identification and prioritization at the local supply chain level. This study therefore focuses on analyzing and prioritizing risks in the salt supply chain of Padang City using a structured House of Risk approach, without extending beyond the observed operational conditions.

This study examines the risk management of the salt supply chain in Padang City, the capital city of West Sumatra Province, Indonesia. This study focuses on a case study of PT Tani Makmur Sejahtera Bersama (TMSB). [8], [16], [17] stated that risks triggered by sustainability issues must be appropriately managed to ensure the sustainability of supply. The decline in salt production can affect all activities of raw material suppliers, processing, and salt distribution. The salt business has several risks that will result in losses if not handled by supply chain actors. These losses for suppliers can be in the form of supplies that do not match demand, both in quantity and delivery time. If this risk is not appropriately handled, salt production processing can be severely disrupted; for example, producers may struggle to meet consumer demand or produce goods that do not meet standards. Salt distribution will also be

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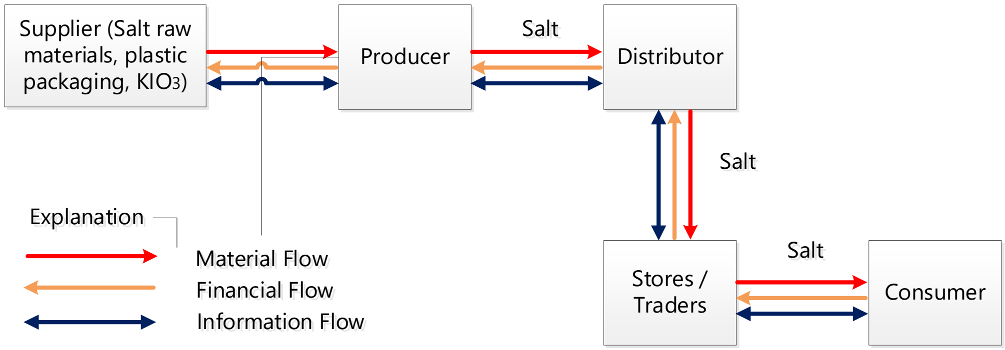

Fig. 1. Generic Salt Supply Chain Flow

disrupted; for example, the amount sent or the delivery time does not match the agreement between the company and the consumer.

The salt produced by TMSB is a type of salt with a rough crystalline form. TMSB produces coarse salt and acceptable salt with an average amount of 500 tons per month. TMSB has been expected to be able to meet local salt needs and to compete with other salt companies in the city. At the same time, TMSB also needs to create a good supply chain flow to avoid various risks that will cause the company to fail in producing salt [2], [18]. To provide a clearer understanding of the operational structure under study, the salt supply chain activities of TMSB are illustrated in Figure 1.

Preliminary observations through interviews with TMSB top management identified several critical risk conditions as follows.

1. Machine damage during the production process that occurs suddenly.
2. Salt producers only have one machine, a mixer or iodization machine used to mix salt, water, and potassium iodate solution. As a result, the device can experience erratic damage.
3. Damage to the engine may occur twice in a month. If the machine stops operating or suffers a failure, the company will incur losses due to decreasing salt production.
4. The level of KIO3 contained in salt was still lacking or not following the standard, which was 30-80 ppm [19]. A laboratory assistant can measure KIO3 levels once every six months in a laboratory owned by TMSB or at the Padang Industrial Research and Technology Center.
5. The inaccuracy of workers in dissolving water and KIO3 may lead to a lack of KIO3 content in salt. As a result, the composition of salt, water, and KIO3 is not proper, so that the results of mixing raw materials are not optimal.

Therefore, companies face risks at every stage of their supply chain. This study therefore proposes a structured risk analysis using the House of Risk (HOR) approach to identify and prioritize risk events and their corresponding risk agents. The study further proposes handling strategies that can be implemented by companies to reduce the likelihood of risk agents in their supply chain [20]. In this paper, the salt supply chain is viewed from the situation found in Padang City, not only from the general issue of salt as a commodity. Field conditions are used to describe how the risks occur in the actual supply chain. The discussion then moves to the main risks, their causes, and the mitigation actions that should be handled first to support supply chain performance and resilience.

METHODS

The House of Risk (HOR) method was used as the main tool for assessing risks in the salt supply chain [7], [21]. HOR was considered suitable because it helps identify, assess, and prioritize risks while still taking into account the conditions found in the case study. Before the risk analysis was carried out, a field survey and literature review were conducted to obtain an initial understanding of the structure and characteristics of the salt supply chain [10], [22], [23].

The risk assessment was arranged as a scoring process so that the responses could be evaluated consistently. Risk events and risk agents were assessed using a scoring system adapted from Failure Mode and Effects Analysis (FMEA). Severity (S) and occurrence (O) were evaluated using a 1–10 scale. This scale was used to combine field-based judgments with an indication of probability, allowing the assessment results to be compared across the supply chain actors.

In this assessment, severity refers to the impact that a risk event may have on daily operations. Occurrence refers to how often, or how likely, a risk agent may appear. The respondents gave scores based on their experience in the salt supply chain. After all responses had been collected, the scores were averaged and used as the final input for the analysis. This averaging was needed so that judgments from different actors could be placed on a comparable basis.

HOR Phase 1 was applied to identify and rank the causes of risk in the salt supply chain. In this phase, the supply chain activities were first mapped. Risk events and related risk agents were then identified from the observed activities. After that, severity, occurrence, and correlation values were used to calculate the Aggregate Risk Potential (ARP) [9], [10], [24]. The correlation between a risk event and a risk agent was scored by experts using the values 0, 1, 3, and 9. These values indicate no, weak, moderate, and strong relationships. The scores from the experts were put together so that the result did not depend on one person only. This also made the analysis easier to check and follow. The priority risk agents from HOR Phase 1 were then used as the basis for HOR Phase 2 [7], [21]. At this stage, preventive actions were prepared and compared. Each action was checked by looking at its expected effect and the difficulty of applying it [9], [25]. The selected actions were expected to fit the dominant risk causes and remain possible for the actors to carry out. Figure 2 presents the research workflow.

The identified risk events and risk agents were then arranged into a questionnaire for the risk analysis stage. Before distribution, the questionnaire was reviewed by four experts: Prof. Rika Ampuh Hadiguna, a supply chain expert and academician at Andalas University; Mr. Ahmad Zaini, an expert in salt production and marketing; and Mrs. Yusra and Mrs. Elfrida, academics from the Department of Marine Sciences, Bung Hatta University, Padang. This validation was carried out to check whether the questionnaire items were relevant to the case context and practical for field use. It was not intended to support statistical generalization beyond the case being studied. The experts were selected because their backgrounds covered supply chain management, salt production and marketing, and marine sciences. Following the validation stage, the questionnaire was distributed to respondents from the main stages of the salt supply chain, namely suppliers, producers, distributors, retailers, and end-consumers. The survey involved 27 retailers and 44 end-consumers. These numbers were obtained based on data adequacy testing. Data collection was mainly directed at retailers and end-consumers because they represent the downstream part of the supply chain. Respondents were selected using a structured sampling approach so that relevant supply chain actors were adequately represented.

The validation process was carried out through repeated expert review. Each expert examined the identified risk items independently, especially in terms of relevance and clarity. When differences in judgment appeared, they were discussed until an agreement was reached. The final questionnaire was then adjusted to the actual operational conditions of the salt supply chain and used for the subsequent risk assessment.

The House of Risk (HOR) method was divided into two models, i.e., HOR 1 and HOR 2. The HOQ 1 determines which causes of risk will prioritize preventive action, the HOR 2 prioritizes preventive measures based on effectiveness, feasible cost, and resource availability. Detailed descriptions of identified risk events and risk agents are presented in the Results section.

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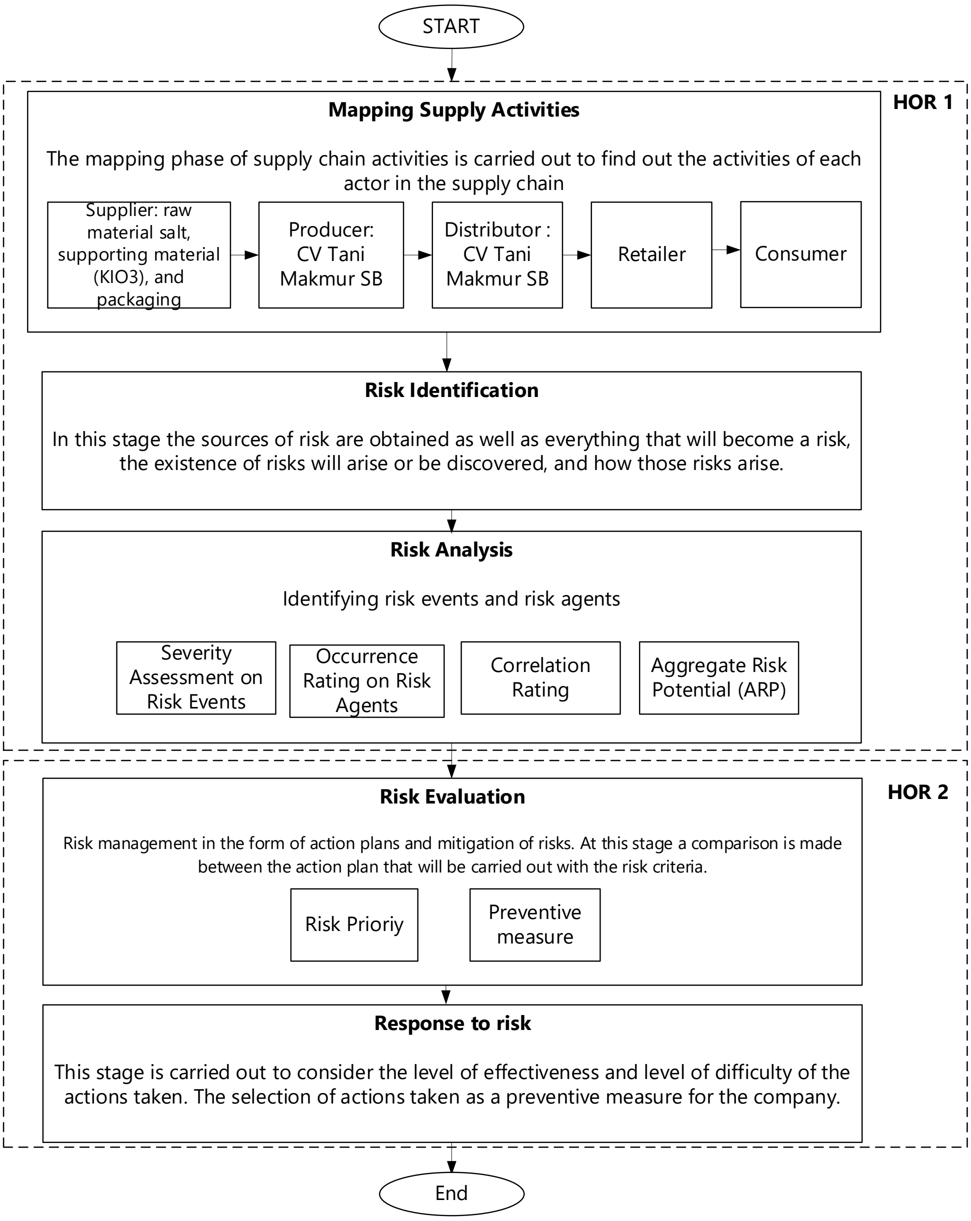

Fig. 2. Research methodology workflow

The stages of risk analysis have been carried out to find out the causes of priority risks. The severity impact and severity level assessments were ranked using the Failure Mode and Effect Analysis (FMEA) method. Although the traditional FMEA framework introduces Risk Priority Number (RPN) as a risk ranking metric, this study adopts Aggregate Risk Potential (ARP) within the House of Risk framework as the primary prioritization measure. ARP extends the RPN concept by incorporating the interaction between multiple risk events and risk agents, enabling a more comprehensive evaluation of systemic risk [10], [24]. The next step is to determine the ranking of risks based on assessing severity, occurrence, and correlation through the calculation of the ARP values. ARP values are calculated using Equation (1).

$$ARP_j = O_j \sum_i S_i R_{ij} \tag{1}$$

where:

ARP_j = Aggregate potential risk to the risk agent j

O_j = Possibility of risk agent j (occurrence)
S_i = Frequency of risk impact i that appears on the risk agent (severity)
R_{ij} = Correlation between risk agent j and risk events i

Risk evaluation is the first stage in HOR 2. This stage is used to follow up on the selected risk causes in the risk analysis stage based on the 80:20 Pareto curve. It is used to design preventive measures to minimize the possibility of risk causes. The response to risk stage is the stage to respond to the proposed preventive measures due to the risk evaluation stage. This stage assesses the effectiveness of the proposed preventive measures and the difficulty of applying them to the selected risk causes. Data processing and risk prioritization analysis were conducted using spreadsheet-based calculations (Ms. Excel). The comparison between the efficacy and degree of difficulty of the proposed preventive measures is called the total effectiveness score based on the degree of difficulty (ETD_k).

Prior to calculating ETD_k, the total effectiveness (TE_k) is first computed using Equation (2).

$$TE_k = \sum_j ARP_j \, E_{jk} \tag{2}$$

where

TE_k = Total effectiveness
ARP_j = Aggregate potential risk for risk agents j
E_{jk} = Correlation between preventive action k with risk agent j, rated {0,1,3,9}

Then ETD_k is calculated using the Formula (3).

$$ETD_k = \frac{TE_k}{D_k} \tag{3}$$

where

ETD_k = Total effectiveness at difficulty level k
TE_k = Total effectiveness
D_k = Degree of difficulty for preventive action k

RESULTS AND DISCUSSION

This section discusses the results of the House of Risk (HOR) stage 1 analysis and explains how the findings were interpreted. For HOR stage 1, the analysis started with activity mapping, followed by risk identification and risk analysis. This was done to trace where the risks occurred along the salt supply chain. The case involved five main actors: raw material suppliers, processing companies, distributors, traders, and consumers. Because these actors are connected, a disturbance in one part of the chain may affect activities in another part. The supply chain structure is presented in Figure 1.

From this process, 35 risk events and 30 risk agents were identified. The risks appeared in more than one activity and involved different actors in the chain. Some risks were direct operational problems. Others were causes that could trigger those problems. The risk events and the related risk agents are shown in Table 1.

The analysis identified 30 risk agents. These agents show that several risk events came from a more limited number of causes. After the list was completed, the analysis was continued by selecting the agents that required more attention in the salt supply chain.

In HOR, the priority of each risk agent is determined using the Aggregate Risk Potential (ARP). ARP is calculated by combining the severity of each risk event, the likelihood that a risk agent will occur, and the strength of the relationship between the risk event and the risk agent. The Pareto curve and ABC method were applied after the

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Table 1. Risk Events and Risk Agents for Supply Chain Actors

Supply Chain Actors	Code	Risk Event	Risk Agent
Procurement of Potassium Iodate	E1	Adequacy of raw materials is limited	Iodine bookings are not scheduled
	E2	Late product delivery to the company	Incorrect in considering the number of bookings
Procurement of plastic packaging	E3	Errors in packaging design and color	Negligence of workers during the production process
	E4	Fluctuations in product demand	Calculation error in planning material packaging needs
Salt Procurement (Garam Ltd.)	E5	Fluctuations in raw material salt prices	Sudden demand from producers
	E6	An accident occurred in the distribution of salt to producers	Uncertain weather factors such as rain
	E7	The process of ordering until receiving salt is quite long	Natural disaster
	E8	The low quality of the salt produced	Inaccuracy in the inspection of salt to be sent
	E9	Adequacy of raw materials is limited	The amount of raw materials ordered is lacking
	E10	Production not on time	Unscheduled raw material ordering
	E11	Late product shipment to the Company	Incorrect in calculating the number of orders
Salt Producer (TMSB Ltd.)	E12	Salt quality is not appropriate	Inspections carried out are not optimal
	E13	Salt mixed with water	Error in the packing process
	E14	Changes in rupiah exchange rates and bank interest	Government policies, such as rising fuel prices
	E15	Lack of KIO_3 levels	Damage to production equipment
	E16	The low quality of the salt produced	Still using machines with simple technology
	E17	Limited production capacity	Competitor Products
	E18	Production process that is not on schedule	Uncertain weather factors such as rain
	E19	Supplier loyalty	Human negligence during the process of delivering goods
	E20	Fluctuations in salt demand	Limited number of conveyances
Distributor (TMSB Ltd.)	E21	Transportation delays	Government policies, such as rising fuel prices
	E22	Damage to the salt product at the time of shipment	Insufficient storage facilities
	E23	An accident occurred in the process of distribution to traders (retail)	Sudden salt demand
	E24	Transport capacity limitations	Unscheduled product order
	E25	Storage damage	Uncertain weather factors such as rain
	E26	Fluctuations in salt demand	Fluctuations in consumer demand
Retailer	E27	The adequacy of salt in stores is limited	Government policies, such as rising fuel prices
	E28	Unclean salt packaging	Government policy changes, including fuel price increases
	E29	Delay in the entry of salt into the store	Limited storage facilities

Table 1. (Cont.)

Supply Chain Actors	Code	Risk Event	Risk Agent
Retailer	E30	The number of products ordered is lacking	Storage errors in salt handling
	E31	Fluctuations in salt prices	Risk Agent
Consumer	E32	Fluctuations in salt prices	Iodine bookings are not scheduled
	E33	Salt is damaged because it has been stored for too long	Incorrect in considering the number of bookings
	E34	Salt is mixed with water or foreign matter	Negligence of workers during the production process
	E35	Salt packaging leaked	Calculation error in planning material packaging needs

Table 2. Classification of Risk Agents Based on Risk Causes

No.	Code	ARP	%ARP Cumulative	Class	No.	Code	ARP	%ARP Cumulative	Class
1	A6	408.33	14.62%	A	16	A24	50.90	90.00%	C
2	A11	300.00	25.37%		17	A17	49.63	91.78%	
3	A10	261.67	34.74%		18	A19	45.51	93.41%	
4	A15	208.44	42.21%		19	A29	39.66	94.83%	
5	A13	172.59	48.39%		20	A2	30.00	95.91%	
6	A14	168.00	54.40%		21	A26	28.67	96.93%	
7	A12	162.67	60.23%	B	22	A25	18.77	97.60%	
8	A9	158.33	65.90%		23	A1	18.00	98.25%	
9	A7	145.00	71.09%		24	A23	14.75	98.78%	
10	A20	105.63	74.88%		25	A30	12.47	99.22%	
11	A16	98.22	78.40%		26	A4	9.00	99.55%	
12	A22	91.26	81.66%		27	A27	6.51	99.78%	
13	A5	70.67	84.20%	C	28	A3	4.00	99.92%	
14	A18	57.04	86.24%		29	A28	2.14	100.00%	
15	A21	54.24	88.18%		30	A8	0.00	100.00%	
						Total	**2,792.10**		

ARP values had been obtained. Table 2 shows the resulting classification. From this classification, the risk agents with the largest contribution to risk exposure could be separated from those with lower priority. Table 2 indicates that the overall risk exposure is concentrated in a limited number of risk agents. Most of the aggregated risk potential comes from agents in Groups A and B. For this reason, mitigation efforts need to be directed first to these groups, as improvements in these areas are expected to have a greater effect on reducing risk in the system.

Table 3 presents the dominant risk agents from Groups A and B and the preventive actions proposed for each of them. The preventive actions in Table 3 are mostly related to problems that appear in daily operations. These actions deal with raw material estimation, coordination between actors, and control of daily routines. This fits the risk agents found in the study, since the problems do not come only from internal activities. Some are linked to changes in demand, raw material supply, and distribution. Because of this, mitigation needs both process improvement and the ability to respond when external conditions change.

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Table 3. Classification of Preventive Actions

Code	Risk Agents	Preventive Action	Code
A6	Weather uncertainty, especially rainfall	Maintain a safety stock when rainfall risk is high	PA1
A7	Natural disaster	Develop cooperation with suppliers from other regions	PA2
		Select alternative routes for raw material delivery	PA3
A9	The amount of raw materials ordered is lacking	Use recent demand records to estimate raw material needs	PA4
A10	Poorly scheduled raw material ordering	Plan the raw material ordering schedule earlier	PA5
A11	Incorrect in calculating the number of orders	Conduct routine checks to avoid ordering errors	PA6
A12	Inspections carried out are not optimal	Conduct regular monitoring and checking of incoming raw materials	PA7
		Prepare a checksheet to facilitate checking incoming raw materials	PA8
A13	Error in the packing process	Group places based on packaging size	PA9
A14	Government policies, such as rising fuel prices	Association with fellow salt producers	PA10
A15	Damage to production equipment	Create a regular maintenance schedule	PA11
A16	Still using machines with simple technology	Improve the mixing machine capacity for salt, water, and KIO_3	PA12
		Improve packaging by using a sealer or plastic press machine	PA13
		Replace old machines with new machines with larger capacities	PA14
A20	Limited number of conveyances	Coordinate product distribution with the fleet or transporter	PA15
A22	Insufficient storage facilities	Store salt in sealed or airtight containers	PA16
		Clean the work environment regularly and continuously	PA17

Table 4. Classification of Preventive Actions

No.	Code	ETD_k	% Cumulative	Classification	No.	Code	ETD_k	% Cumulative	Classification
1	PA7	1,488.00	16.17%	A	9	PA16	425.88	89.94%	C
2	PA5	1,410.33	31.49%		10	PA12	271.61	92.89%	
3	PA4	1,372.26	46.40%		11	PA10	203.57	95.10%	
4	PA6	1,027.07	57.56%		12	PA13	135.80	96.58%	
5	PA1	923.43	67.59%	B	13	PA17	119.78	97.88%	
6	PA8	567.00	73.75%		14	PA3	75.00	98.70%	
7	PA11	548.79	79.71%		15	PA2	50.00	99.24%	
8	PA15	515.67	85.31%		16	PA14	35.21	99.62%	
					17	PA9	34.86	100.00%	
						Total	**9,204.25**		

Table 4 gives the ETD_k values for the proposed actions. The values were used to see whether the benefit of an action was worth the difficulty of applying it. The calculation follows the House of Risk procedure used in previous studies [26], [27]. In this study, ETD_k helped select actions that were useful enough compared with the effort needed for implementation.

Demand, production planning, and coordination between stages may affect how the proposed actions can be applied. In this study, these factors were not measured as separate results. They were used only as field context, especially to understand why some actions seemed easier or more useful than others. Distribution is another issue that should be considered. Salt products need reliable transport and clear delivery arrangements because the market is not located in one place. In this case, logistics is more than sending products from one point to another. It also influences whether a proposed action can actually be carried out by the actors.

The discussion in this study is limited to the House of Risk results. The preventive actions were identified and discussed with the relevant actors, but the study did not observe their use in daily operations. For that reason, the long-term performance of these actions was not evaluated. The results should be read as findings from the Padang City case. Other supply chains may have different sizes, structures, market patterns, and coordination practices. These differences can change the order of priorities. Still, the results show that risk mapping can help actors decide which problems need to be handled first under actual operating conditions.

CONCLUSION

In the Padang City case, risks were found in different parts of the salt supply chain. They appeared not only in production, but also in supply, distribution, and coordination activities. The House of Risk method was used to connect the observed risk events with their possible causes. From this process, the study showed which causes needed more attention because they were related to more than one risk event. Based on the HOR analysis, mitigation should begin with risk agents that have high influence but can still be managed by the actors involved. The comparison between the expected effect of each action and the difficulty of implementation also shows which actions are more realistic to apply. A more useful approach is to focus first on the risk agents that are both influential and realistically manageable. By comparing the expected effect of each preventive action with the difficulty of carrying it out, the proposed approach helps identify actions that are practical for the actors involved. Although the study was carried out in the salt industry, the way the analysis is structured may still be relevant for other commodity-based supply chains with similar conditions. Future work could involve a wider group of actors to see whether different positions in the supply chain led to different views of risk and mitigation priorities. In this sense, the study does not only rank risks, but also shows how structured risk mapping can support more grounded and adaptive decisions in supply chain risk management.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

[1] T. H. Tran, M. Dobrovnik, and S. Kummer, "Supply Chain Risk Assessment: A Content Analysis-Based Literature Review," *Int J Logist Syst and Manag*, vol. 31, no. 4, 2018, doi: 10.1504/IJLSM.2018.096088.

[2] A. Emrouznejad, S. Abbasi, and C. Sicakyuz, "Supply Chain Risk Management: A Content Analysis-Based Review of Existing and Emerging Topics," *Supply Chain Analytics*, vol. 3, 2023, doi: 10.1016/j.sca.2023.100031.

[3] R. Chatchai and J. Liangrokapart, "Supply Chain Risk Management: A Case Study in Thailand," in The Hamburg International Conference of Logistics, 2015, pp. 557–579.

[4] M. A. Adeseun, A. I. Anosike, J. A. G. Reyes, and M. Al-Talib, "Supply Chain Risk Perception: Understanding The Gap Between Theory and Practice," *IFAC Papers OnLine*, vol. 51, no. 11, pp. 1701–1706, 2018, doi: 10.1016/j.ifacol.2018.08.211.

[5] I. Heckmann, T. Comes, and S. Nickel, "A Critical Review on Supply Chain Risk–Definition, Measure and Modeling," *Omega (Westport)*, vol. 52, pp. 119–132, 2015, doi: 10.1016/j.omega.2014.10.004.

[6] T. Immawan and D. K. Putri, "House of Risk Approach for Assessing Supply Chain Risk Management Strategies: A Case Study in Crumb Rubber Company Ltd," in *MATEC Web of Conferences* 154, 2018, doi: 10.1051/matecconf/201815401097.

[7] S. Kurniawan, D. Marzuky, R. Ryanto, and V. Agustine, "Risk and Supply Chain Mitigation Analysis Using House of Risk Method and Analytical Network Process(A Case Study on Palm Oil Company)," *The Winners,* vol. 22, no. 2, pp. 123–136, Sep. 2021, doi: 10.21512/tw.v22i2.7056

[8] R. A. Hadiguna, "Model Penilaian Risiko Berbasis Kinerja untuk Rantai Pasok Kelapa Sawit Berkelanjutan di Indonesia (A Performance-Based Risk Assessment Model for Sustainable Palm Oil Supply Chains in Indonesia)," *Jurnal Teknik Industri (Industrial Engineering Journal)*, vol. 14, no. 1, pp. 13–24, 2012, doi: 10.9744/jti.14.1.13-24.

[9] E. Amrina and Y. A. Wardah, "Risk Assessment of Supply Chain of Hybrid Corn," in *1st International Conference on Industrial and Manufacturing Engineering,* 2019, doi: 10.1088/1757-899X/505/1/012013.

[10] M. Ulfah, M. S. Maarif, Sukardi, and S. Raharja, "Analisis dan Perbaikan Manajemen Risiko Rantai Pasok Gula Rafinasi Dengan Pendekatan House of Risk (Analysis and Improvement of Refined Sugar Supply Chain Risk Management With The House of Risk Approach)," *Jurnal Teknologi Industri Pertanian (Journal of Agricultural Industrial Technology),* vol. 26, no. 1, pp. 87–103, 2016.

[11] Q. Wang and Y. Chen, "Status and Problem Analysis of da-Industrial Salt Supply Chains in China," I*nnovation and Supply Chain Management,* vol. 9, no. 3, pp. 89–94, 2015, doi: 10.14327/iscm.9.89.

[12] A. S. Perbangsa, Febdro, W. Wijaya, A. Amelia, and B. Pardamean, "Model of Web-based Supply Chain Management System for Salt Industry," *International Conference on Information Management and Technology*, 2017, pp. 232–237, doi: 10.1109/ICIMTech.2017.8273543.

[13] A. S. Indrapriyatna, R. Patrisina, A. S. Dea, N. Sulasi, and Y. Sherlyna, "Integrating good manufacturing practices, lean manufacturing, and information technology for operational excellence in Indonesian food SMEs," *Teknosi,* vol. 11, no. 3, pp. 235–243, 2025, doi: 10.25077/TEKNOSI.v11i3.2025.235-243.

[14] Poerwadi B.S., "2016 National Salt Production Fell Sharply Due to La Nina." Accessed: Mar. 20, 2024. [Online]. Available: https://tirto.id/cge

[15] G. Yanginlar, M. E. Civelek, and E. Gulcur, "The Effect of Supply Chain Risk Management on Logistics Performance and Innovation Performance," *Int J Prof Bus Rev*, vol. 8, no. 11, pp. 1–22, Nov. 2023, doi: 10.26668/businessreview/2023.v8i11.3164.

[16] K. Mc Loughlin, K. Lewis, D. Lascelles, and S. Nudurupati, "Sustainability in Supply Chains: Reappraising Business Process Management," *Production Planning & Control*, vol. 34, no. 1, pp. 19–52, 2021, doi: 10.1080/09537287.2021.1884764.

[17] F. G. Dendra, E. Amrina, and A. S. Indrapriyatna, "Inventory Control Model of Beef for Rendang Products," *Jurnal Optimasi Sistem Industri*, vol. 22, no. 1, pp. 22–30, 2023, doi: 10.25077/josi.v22.n1.p22-30.2023.

[18] M. A. Khan, M. A. Qureshi, and M. Irshad, "A Systematic Review on Supply Chain Risk Management: Issues, Challenges, and Future Agenda," P*akistan Languages and Humanities Review,* vol. 6, no. 2, pp. 159–173, 2022, doi: 10.47205/plhr.2022(6-II)14.

[19] Badan Standardisasi Nasional (National Standardization Agency), SNI 3556_2016-Garam Konsumsi Beriodium (Iodized Table Salt). https://kupdf.net/download/129sni-3556-2016_595f3b45dc0d6096492be30d_pdf.

[20] N. A. Choudhary, S. Singh, T. Schoenherr, and M. Ramkumar, "Risk Assessment in Supply Chains: A State-of-the-Art Review of Methodologies and Their Applications," *Ann Oper Res,* vol. 322, pp. 565–607, 2023, doi: 10.1007/s10479-022-04700-9.

[21] I. N. Pujawan, "House of Risk: A Model for Proactive Supply Chain Risk management," *Bus Process Manag J,* vol. 15, no. 6, pp. 953–967, 2009, doi: 10.1108/14637150911003801.

[22] B. R. Kristanto, D. N. Luh, and P. Hariastuti, "Aplikasi House of Risk (HOR) untuk Mitigasi Risiko Pada Supply Chain Bahan Baku Kulit (House of Risk (HOR) Application for Risk Mitigation in Leather Raw Material Supply Chain)," *Jurnal Ilmiah Teknik Industri* , vol. 13, no. 2, pp. 149–157, Dec. 2014.

[23] O. S. Anindyanari and N. B. Puspitasari, "Analisis dan Mitigasi Risiko Rantai Pasok Menggunakan Metode House of Risk pada PT XYZ (Supply Chain Risk Analysis and Mitigation Using the House of Risk Method at PT XYZ)," in Seminar dan Konferensi Nasional IDEC 2021 (IDEC 2021 National Seminar and Conference), Jul. 2021.

[24] Z. Kovács, T. Csizmadia, I. Mihálcz, and Z. T. Kosztyán, "Multipurpose Aggregation in Risk Assessment," *Mathematics*, vol. 10, no. 17, 2022, doi: 10.3390/math10173166.

[25] T. J. Lentz et al., "Aggregate Exposure and Cumulative Risk Assessment—Integrating Occupational and Non-occupational Risk Factors," *J Occup Environ Hyg,* vol. 12, no. 1, 2015, doi: 10.1080/15459624.2015.1060326.

[26] V. Haievskyi, "Study of Possibilities of Joint Application of Pareto Analysis and Risk Analysis During Corrective Actions," *Technology Transfer: Fundamental Principles And Innovative Technical Solutions*, vol. 4, 2020, doi: 10.21303/2585-6847.2020.001536.

[27] Y. He, L. Peng, D. Zhang, and Z. Zhao, "Risk Analysis via Generalized Pareto Distributions," *J Bus Econ Stat,* vol. 40, no. 2, doi: 10.1080/07350015.2021.1874390.

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