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Prioritizing Risks in Production Activities: A Study of Salt Processing Enterprises in the Central Region of Vietnam

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ABSTRACT

Salt production has the common characteristics of agricultural output, always facing many types of risks. This study aims to identify and prioritize risks in the production activities of salt processing enterprises in the Central region of Vietnam. The research combined qualitative and quantitative research methods. The qualitative study conducted in-depth interviews with 12 experts from 6 salt processing enterprises to identify risk criteria. Next, structured interviews were conducted with experts to collect point data comparing each pair of risks, and at the same time, point data on the likelihood of occurrence of risk criteria were collected, and then the analytical hierarchy process was applied to determine the overall weight of the risk criteria, and from there, the risk score value is determined. The results of the study show that 5 risk criteria need to be prioritized for handling, including weather risk (PrPR2), with a risk score value of 3.5833; storage risk (PoPR1), with a risk score value of 2.6520; food safety risk (RIP2), with a risk score value of 2.4630; and coastal environmental pollution risk (PrPR3), with a risk score value of 2.0668; and finally, the risk of delayed production (RIP5), with a risk score value of 1.7112. Based on the above results, the study proposes some management implications to improve the production efficiency of salt processing enterprises in the Central region of Vietnam.

1. INTRODUCTION

Salt is a very important and essential commodity for life [1]. Many archaeological evidences of salt production facilities in ancient Rome show that salt was not only necessary for food preservation but also used in many other production processes. According to Rees [2], before the invention and widespread application of refrigeration in the early 19th and 20th centuries, there were only a few methods that could preserve food, such as drying, smoking, and salting. Of these, salting was the most effective and efficient method. Thus, salt played a fundamental role as a socio-economic driving force of ancient societies and to this day [3-5].

In Vietnam, salt is also an essential commodity, playing an important role in ensuring national food security. Vietnam's salt industry has developed from a long tradition of salt making, with a coastline of 3,260 km from North to South. Vietnam currently has 21 coastal provinces (in the 3 regions of North, Central, and South), but the salt production area is mainly concentrated in the central provinces: Ninh Thuan, Khanh Hoa, Binh Thuan, Ha Tinh, Nghe An, Quang Ngai... Salt products are used as raw materials for a number of industries, such as the chemical industry, seafood processing, food, and pharmaceuticals.

Salt production activities also have the common characteristics of agricultural production activities, always facing many types of risks such as risks of raw materials, weather, coastal environment, food safety, inventory preservation, etc. Therefore, risk identification and prevention are an urgent issue for salt production enterprises in Vietnam in general and salt production enterprises in the Central region in particular to have timely response plans, limiting losses in production activities. However, in reality, enterprises may not have enough resources or cannot respond to all types of risks at the same time. Therefore, the important issue is to analyze, evaluate and prioritize risks to determine their importance so that appropriate risk response attention can be paid [6]. A reasonable and correct approach that managers need to pay attention to at this time is the Analytical Hierarchy Process (AHP) method. AHP is one of the multi-criteria decision-making methods that can assist managers in identifying risks that need to be prioritized for treatment. With AHP, a pairwise comparison matrix is established by the decision maker by comparing the relative importance of criteria to each other according to a separate scale [7].

The objective of this study is to use the AHP method combined with the risk score index and Pareto analysis to determine risk priorities in the salt production activities of salt processing enterprises in the Central region of Vietnam. This study can be useful for salt processing enterprises, helping enterprises identify risks that need to be prioritized and focus on responding to and handling risks to reduce costs, increase profits, and contribute to improving production and business efficiency for enterprises.

2. LITERATURE REVIEW

In recent years, there have been many studies using AHP for different purposes. Toledo et al. [8] assessed risks in agricultural activities in Central South Chile using the AHP method. This study applied the AHP method to determine the decision structure with four risk criteria, including climate, price and direct cost fluctuations, human factors, and commercialization. The weights of the risk criteria were determined, and the result of risk criteria fluctuating with price and cost was the most important criterion. Aminbakhsh et al. [9] assessed safety risks using AHP in planning and budgeting for construction projects. This study argued that prioritizing safety risks is very important in order to be able to manage them well. The study proposed a safety risk assessment framework based on the theory of the cost of safety (COS) model and the AHP method. Mızrak [10] applied the AHP method to manage risks and crises in the logistics industry. The study took an in-depth look at the literature and insights gathered from interviews with five industry experts, which revealed the challenges faced by logistics companies through the application of the AHP method. This study provides a systematic framework for prioritizing strategies based on the importance and potential impact of risks for logistics companies. Zayed et al. [11] evaluated the risks of road projects in China. In this study, four case studies, A, B, C, and D, were selected to implement the designed model and test its results. The R-index model was developed by applying AHP. The results showed that political risk had the highest weight, financial risk had the second highest weight, and emerging technology risk and resource risk had medium weight. In addition, some studies have used methods other than AHP to assess or prioritize risks. Fera et al. [12] applied the ANP method to prioritize risks in wind energy investment decision-making. This study deals with the identification and prioritization of risk factors for wind power plant installation. The identified risks are mainly related to the main stages of a project, such as design, licensing, procurement, construction, commissioning, and maintenance throughout the life of the machine. Ou Yang et al. [13] applied VIKOR to improve information security risks. In this study, the VIKOR method allows decision-makers to understand these gaps in projects/aspects and rank them according to their desired level. Zhang et al. [14] applied DEMATEL to identify key risks in Sponge City PPP projects in China. The DEMATEL method was used in this study to prioritize risks and then analyze their interdependencies to find out the important risks. The study results showed that the important risk factors were inadequate monitoring systems, government intervention, incomplete laws and regulations, project fragmentation, and unclear catchment area boundaries. Salah et al. [15] prioritized hazards in Industry 4.0 using extended FMEA analysis. The RPN, which is typically the product of three factors: severity (S), occurrence (O), and detection (D), was utilized in this investigation. The RPN ratings for I4.0 and conventional components were compared in the research. The FMEA model's application process was thoroughly explained, and its applicability was confirmed and shown. The findings also indicate that certain I4.0 components, like color detection and proximity sensors, are given the greatest priority. After putting the expert group's recommendations into practice, performance improved.

Some studies have combined AHP and other methods to assess or prioritize risks. Huang et al. [16] assessed risks in ERP projects by applying the Delphi method combined with the AHP method. This study used the Delphi method to identify potential risk factors of ERP projects and proposed a hierarchical model based on the AHP method to analyze and prioritize risk factors of ERP projects. Kokangül et al. [17] applied AHP and Fine Kinney to assess risks in the field of occupational health and safety. This study, which was carried out in a sizable manufacturing organization, classified and prioritized the hazards based on statistical records and experience over the previous ten years utilizing the AHP method. The Fine Kinney approach was also used to assess the risks found in this field. The strategy provided in this study was devised on the basis of the fact that the data generated using the AHP method may be employed with the Fine Kinney risk assessment method. Prasanna Venkatesan and Kumanan [18] applied the AHP method and the PROMETHEE method to prioritize supply chain risks. A typical example of a plastics industry is presented to illustrate the performance of the proposed approach. Baylan [19] has developed a project risk assessment scheme through the combination of the AHP and TOPSIS methods. The AHP model is being used in this study to rank work packages based on the relative significance of project time, project output quality, and project cost. The TOPSIS technique uses the breakdown structure of these task packages as input for the weighted criterion. In the second layer of this decision method, the TOPSIS model is used to prioritize pre-defined operational risks according to the success criteria of weighted project work packages. The findings demonstrate that the use of TOPSIS and AHP offers a framework for quantitative project risk analysis at the project activity level as well. Wang et al. [20] integrated the AHP and DEA methods to assess bridge project risks. The AHP method is used to determine the weights of the criteria; the DEA data coverage analysis method is used to determine the values of the linguistic terms; the simple additive weighting (SAW) method is used to aggregate the bridge risks according to various criteria into an overall risk score for each bridge project; and the linguistic terms, such as high, medium, low, and none, are used to assess the bridge risk according to each criterion. Komazec et al. [21] used AHP to assess the risks on the Piraeus-Belgrade-Budapest railway corridor. Avcı and Koca [22] applied AHP to analyze all possible security risks for smart railway systems. Mohamed Said et al. [23] used a combination of AHP and SCOR methods to identify and assess transportation risks in the petroleum supply chain. This study uses a combination of AHP, risk score (RS), and Pareto analysis to prioritize risks in production activities, studying the case of salt production enterprises in the Central region of Vietnam. The risk score is usually the product of two factors: impact level and frequency of occurrence. Pareto analysis is predicated on the notion that completing 20 percent of the effort may provide 80 percent of the project's benefits; it is sometimes referred to as the 80/20 rule. Conversely, 80 percent of the problems of a situation can originate from 20 percent of the causes [24]. AHP is a complex system that is studied as a hierarchy of elements. Each hierarchy's components are compared pairwise on a nominal scale. The comparison weights between various members of a particular hierarchy are then represented by the eigenvectors of the comparison matrix, which is created by quantifying the comparisons. Finally, the eigenvalues are used to evaluate the consistency ratio strength of the comparison matrix and determine whether the information is acceptable [25].

3. METHODOLOGY

3.1 Research design

To prioritize risks in the production activities of salt processing enterprises in the Central region of Vietnam, the AHP method combined with the Risk Score index and Pareto analysis was used in this study. The research procedure is described in Figure 1.

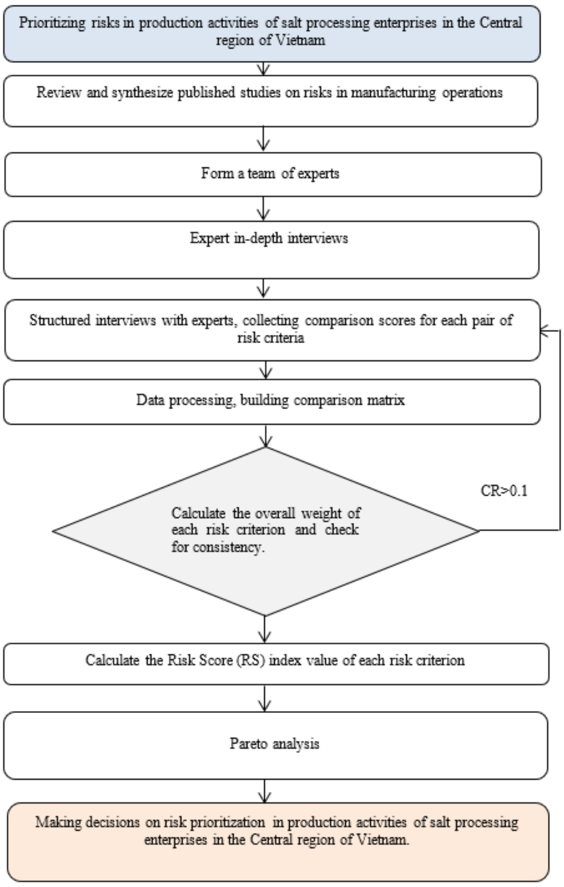

Figure 1. Research framework

3.2 Qualitative research

3.2.1 Synthesis of studies on risks in production activities

The studies reviewed by the authors include: Indrawati et al. [26]; Van Asselt et al. [27]; Javed et al. [28]; Relkar [29]; Sales et al. [30]; Michalak [31]; Helbig et al. [32]; Nilsen [33]; Nowacki [34].

The preliminary list of 8 risk criteria selected by the authors includes work accident risk, food safety risk, transportation risk, equipment failure risk, inventory management risk, weather risk, raw material supply, and production delay.

3.2.2 Form a team of experts

The expert group consists of 12 members from 6 enterprises specializing in salt production, including 6 directors and 6 factory managers. These are experts with many years of experience and understanding in the field of salt production and processing in Central Vietnam. At the same time, in this expert group, there are also 12 salt workers who have been working in the salt industry for many years.

3.2.3 Expert in-depth interviews

Before conducting the in-depth interviews, the authors sent an email to each expert. The email content asked the experts to consider 8 risk criteria that the authors had preliminarily selected. The in-depth interviews followed.

(1) Objective of in-depth interview: Review risk criteria; which risk criteria need to be eliminated or added? Classify and rank risk criteria.

(2) Participants in in-depth interviews include 12 experts; they are 6 directors and 6 heads of production workshops from 6 enterprises specializing in salt production in the Central region of Vietnam.

(3) Time: In-depth interviews were conducted 3 times. The time for each official discussion and exchange with each expert is from 25 minutes to 40 minutes, not including the time for contacting, responding to comments, and agreeing on opinions.

As a result of the qualitative research, the experts added 3 risk factors to the list of risks, including coastal environmental pollution, preservation risk, and the risk of experienced workers quitting. These 3 risk factors were included in the model by the experts based on the reality at the enterprise. Through active consideration and discussion, all the experts agreed to include these 3 risks in the research model. The experts and the group of authors classified the risks into 3 types, and those are the 3 stages of the entire production process: pre-production, production, and post-production. The hierarchy table and hierarchy model of risk criteria in production activities of salt processing enterprises in the Central region are presented in Table 1 and Figure 2, respectively.

Table 1. Hierarchy of risk criteria in salt production activities

Level 1 Risk Criteria	Level 2 Risk Criteria	Research Sources
Pre-Production risk (PrPR)	Sourcing of raw materials (PrPR1)	Helbig et al. [32]
	Weather Risk (PrPR2)	Michalak [31]
	Coastal environmental pollution (PrPR3)	In-depth interviews
	Transportation risks (PrPR4)	Javed et al. [28]
Risk in production (RIP)	Risk of damage to machinery and equipment (RIP1)	Relkar [29]
	Food safety risks (RIP2)	Van Asselt et al. [27]
	Risk of occupational accidents (RIP3)	Nowacki [34]
	Risk of experienced workers quitting (RIP4)	In-depth interviews
	Production is delayed (RIP5)	Nilsen [33]
Post-production risk (PoPR)	Storage risk (PoPR1)	In-depth interviews
	Inventory Management Risks (PoPR2)	Sales et al. [27]

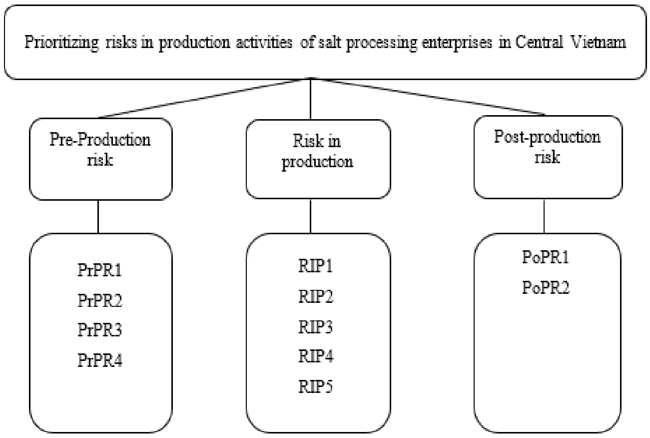

Figure 2. Hierarchical diagram of risk priority model in salt production activities

3.3 Quantitative research

3.3.1 Structured interviews with experts, collecting comparison scores for each pair of risk criteria

The data collection tool used by the author in the quantitative research was the use of structured interviews with experts using a detailed questionnaire. The questionnaire consists of 3 parts:

Part 1: The author presents a list of risk criteria in salt production activities that were agreed upon during the in-depth interviews.

Part 2: Includes questions comparing the relative importance of each pair of risk criteria. The scale used in the questionnaire for comparing each pair is presented in Table 2.

Part 3: Includes questions collecting data for experts' scores on the likelihood of each risk criterion.

Partial illustrations of the results of this step are shown in Tables 3 and 4.

Table 2. Pairwise comparison scale of importance

Definition of Importance	Explanation	Intensity
Extreme importance	An activity is overwhelmingly favored over another.	9
Very, very strong		8
Very strong	An activity is favored very strongly over another.	7
Strong plus		6
Strong importance	Experience and judgement strongly favour one activity.	5
Moderate plus		4
Moderate importance	Experience and judgement slightly favour one activity.	3
Weak or slight		2
Equal importance	Two activities contribute equally to the objective.	1

Source [35]

Table 3. Illustration of the results of the expert pairwise comparison

No.	Left Criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Right Criteria
1	Sourcing of raw materials (PrPR1)										x								Weather Risk (PrPR2)
2	Sourcing of raw materials (PrPR1)								x										Coastal environmental pollution (PrPR3)

Table 4. Illustration of expert risk likelihood scoring results

Risk Criteria	Symbol	Expert Score											
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Sourcing of raw materials	PrPR1	2	2	1	2	2	2	2	1	2	2	2	2
Weather Risk	PrPR2	3	3	4	4	4	3	3	3	4	4	4	4
Coastal environmental pollution	PrPR3	5	5	5	5	4	4	5	4	5	5	4	5

The experts participating in the structured interview included experts who had participated in the in-depth interview, in addition to 12 salt workers working in the salt industry. To create objectivity in the perception and viewpoint of each expert, the author interviewed each expert independently, in turn, from the first expert to the last expert. By contrasting every risk combination with one another, the goal was to determine the risk criteria importance. It should be noted that the experts must first prioritize the risk criteria according to their feelings and then proceed to compare the importance of each pair of risk criteria.

For collecting data for experts' scoring of the likelihood of each risk criterion. To have a more accurate assessment, closer to reality. With 2 criteria: weather risk (PrPR2) and coastal environmental pollution risk (PrPR3). The author team will collect data from 12 salt workers working in the salt field instead of from 6 directors and 6 factory managers.

3.3.2 Data processing, building comparison matrix

After having collected primary data from interviews with experts, the author proceeded to process the data to build comparison matrices of risk criteria. The principle of data processing is to get the majority of experts' opinions similar in determining which criteria are more important and in assigning points when comparing pairs of risk criteria.

The construction of comparison matrices follows the following principle:

- If the value being evaluated-weighted is to the left of number 1, then record that value exactly in the matrix.
- If the value being evaluated-weighted is to the right of number 1, then record the number equal to the inverse of that evaluation value in the matrix.

The results of the comparison matrix of pairs of risk criteria are shown in Tables 5 to 8.

Level 1 Risk Criteria Comparison Matrix

Table 5. Pairwise comparison matrix of level 1 risk criteria

Criteria	PrPR	RIP	PoPR
PrPR	1	2	2
RIP	1/2	1	1
PoPR	1/2	1	1

Comparison matrix of level 2 risk criteria under level 1 risk - Pre-production risk

Table 6. Pairwise comparison matrix of level 2 risk criteria—Pre-production risk

Criteria	PrPR1	PrPR2	PrPR3	PrPR4
PrPR1	1	1/2	2	3
PrPR2	2	1	3	4
PrPR3	1/2	1/3	1	2
PrPR4	1/3	1/4	1/2	1

Comparison matrix of level 2 risk criteria under level 1 risk - Risk in production

Table 7. Pairwise comparison matrix of level 2 risk criteria - Risk in production

Criteria	RIP1	RIP2	RIP3	RIP4	RIP5
RIP1	1	1/3	2	3	1/2
RIP2	3	1	5	7	2
RIP3	1/2	1/5	1	2	1/3
RIP4	1/3	1/7	1/2	1	1/4
RIP5	2	1/2	3	4	1

Comparison matrix of level 2 risk criteria under level 1 risk—Post-production risk

Table 8. Pairwise comparison matrix of level 2 risk criteria—Post-production risk

Criteria	PoPR1	PoPR2
PoPR1	1	2
PoPR2	1/2	1

3.3.3 Calculate the overall weight of each risk criterion and check for consistency

Next, the author will calculate the general weight of the risk criteria. The calculation tool used by the author is Excel software; the steps are as follows:

Step 1: Find the priority vector along with the weights of the level 1 risk criteria (global weight).

Step 2: Find the priority vector along with the weights of the level 2 risk criteria (local weight).

The calculation of finding vectors is performed on each matrix one by one by summing the values of the matrix by column; then each value of the matrix will be divided by the sum of the values of the corresponding column, and the obtained value is substituted for the calculated value. The weight of each criterion (C1, C2, C3, … Cn) will be equal to the average of the values in each horizontal row. The result is a 1-column n-row matrix. The calculated value is only accepted when the consistency ratio CR <= 10% (0.1); if the consistency coefficient is greater than 10%, the expert's comparison result must be checked again [35]. With CI, CR is calculated according to the following formula: Consistency ratio CR: CR = CI/RI.

In which: RI: is the random consistency index (Table 9); CI: is the consistency index CI= (λ max-n)/n-1. λ max: is the eigenvalue of the matrix, λ max= $\sum_{i=1}^{n} wi \times \sum_{j=1}^{n} aij$.

Step 3: Calculate the overall weight.

Table 9. Random consistency index

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source [36]

3.3.4 Calculate the risk score value of each risk criterion

The risk score (RS) will be calculated according to Eq. (1) referenced from Hossen et al. [37].

$$\text{Risk Score} = \text{Impact} \times \text{Frequency of Occurrence} \quad (1)$$

Calculating the Impact Level: Once the overall weight has been determined, the overall weight will then be converted into an impact level [37]. Accordingly, the risk factor with the highest overall weight will be assigned the highest impact level of 0.8, and the criterion with the lowest weight will be assigned the smallest value of 0.05. The impact levels of the remaining factors will be calculated in turn using the linear interpolation method. The impact level of the risk will be given according to 5 levels, from 1 to 5, shown in Table 10.

Table 10. Scale of impact level of risks

Level	Definition of Impact Level	Description
5	Very serious	Reasons for business closure/bankruptcy
4	Serious	Serious impact
3	Medium	Medium impact
2	Mild	Has limited impact
1	Very mild	Very low impact

Source: [38]

Calculating the frequency of occurrence: The results obtained from the questionnaire survey on the likelihood of occurrence of risk factors will be used to calculate the frequency of occurrence.

The frequency of occurrence will be calculated according to Eq. (2) referenced from Hossen et al. [37].

$$\text{Frequency of occurrence} = \frac{\sum a_i \times n_i}{A \times N} \quad (2)$$

where,

a_i is the weight given to each risk factor (weight from 1 to 5).

n_i is the number of times that weight appears (according to the expert's score).

A is the highest weight = 5.

N is the total number of respondents (number of experts).

The frequency of the risk occurrence will be standardized according to 5 levels, from 1 to 5, shown in Table 11.

3.3.5 Pareto analysis

Pareto analysis is conducted in two main steps. The first step is to identify, classify, and stratify problems, specifically things like errors, defects, delays, etc., and then evaluate and score each problem. Second, it is to display the results in graphic form in a Pareto chart or Pareto diagram so that a few important problems emerge from the general context [24]. In this study, the first main step was carried out by the authors through the implementation of the steps of the AHP method and the calculation of the risk score index. The second main step of Pareto analysis is that the authors draw a Pareto chart; the drawing support tool is Excel software. With a Pareto chart, the line reflects the cumulative percentage of factors that are the principal components. When the cumulative percentage line reaches ≥ 80%, this means that all the factors combined before represent 20% of the causes (i.e., the important few). Remember that the 80/20 rule is a rough guide to typical distributions based on the Pareto principle, so the numbers are not exact, and the total may not add up to 100%. The Pareto chart actually highlights that the weight or impact of the factors that contribute to a particular outcome is not equal [39].

Table 11. Scale of likelihood of risks

Level	Definition of Occurrence Frequency	Description
5	Very high	Every day
4	High	Once a week
3	Medium	Once a month
2	Small	Every quarter
1	Very small	Once a year

Source [38]

4. RESULTS

4.1 Expert characteristics

This study conducted in-depth interviews for qualitative research with experts from 6 salt production and processing enterprises in the Central region of Vietnam. The author used the purposive sampling method as an appropriate sampling procedure for this study. To obtain a realistic assessment of risks in salt production activities, relevant experts with 5 years or more of working experience (directors, production workshop managers) of 6 salt production enterprises in the Central region were selected as participants. Most notably, the experts involved in this study have worked in the field of salt production and processing for many years, so the comments and evaluations of the experts are close to reality. Table 12 below further clarifies the characteristics of the experts.

Table 12. Expert characteristics

Job/Responsibilities	Number of Years of Experience	
	From 10 to 15 Years	Over 15 Years
Directors	2 Expert	4 Expert
Head of production workshop	1 Expert	5 Expert
Salt people work in the Salt profession	2 Expert	10 Expert

4.2 Result of the priority vector of risk criteria

The results of the risk criteria priority vectors are shown in Tables 13 to 16.

Table 13. Priority vector of level 1 risk criteria

Criteria	PrPR	RIP	PoPR	Priority Vector
PrPR	1	2	2	0.5000
RIP	1/2	1	1	0.2500
PoPR	1/2	1	1	0.2500

Table 14. Priority vector of level 2 risk criteria—Pre-production risk

Criteria	PrPR1	PrPR2	PrPR3	PrPR4	Priority Vector
PrPR1	1	1/2	2	3	0.2773
PrPR2	2	1	3	4	0.4661
PrPR3	1/2	1/3	1	2	0.1608
PrPR4	1/3	1/4	1/2	1	0.0958

Table 15. Priority vector of level 2 risk criteria—Risk in production

Criteria	RIP1	RIP2	RIP3	RIP4	RIP5	Priority Vector
RIP1	1	1/3	2	3	1/2	0.1543
RIP2	3	1	5	7	2	0.4474
RIP3	1/2	1/5	1	2	1/3	0.0902
RIP4	1/3	1/7	1/2	1	1/4	0.0553
RIP5	2	1/2	3	4	1	0.2529

Table 16. Priority vector of level 2 risk criteria—Post-production risks

Criteria	PoPR1	PoPR2	Priority Vector
PoPR1	1	2	0.6667
PoPR2	1/2	1	0.3333

Priority vector of level 1 risk criteria.

n= 3; λmax= 3; CI= $\frac{\lambda max - n}{n-1} = \frac{3-3}{3-1} = 0$; CR= $\frac{CI}{RI} = \frac{0}{0.58} = 0$. With CR value = 0 <0.1, so consistency in decision-making is guaranteed.

Priority vector of level 2 risk criteria: Pre-production risk.

n= 4; λmax= 4.0347; CI= $\frac{\lambda max - n}{n-1} = \frac{4.0347-4}{4-1} = 0.01157$; CR= $\frac{CI}{RI} = \frac{0.01157}{0.9}$ = 0.01286. With CR value = 0.01286<0.1, so there is consistency in decision-making.

Priority vector of level 2 risk criteria: Risk in production.

n= 5; λmax= 5.0331; CI= $\frac{\lambda max - n}{n-1} = \frac{5.0331-5}{5-1} = 0.00828$; CR= $\frac{CI}{RI} = \frac{0.00828}{1.12}$ = 0.00739. With CR value = 0.00739<0.1, so there is consistency in decision-making.

Priority vector of level 2 risk criteria: Post-production risks.

n= 2, so there is consistency in decision-making.

4.3 Weight of risk criteria

Table 17 shows the weights of the risk criteria.

Table 17. Weight of risk criteria

No.	Risk Criteria	Local Weight	Global Weight	Overall Weight
1	Sourcing of raw materials	0.2773	0.5000	0.1386
2	Weather Risk	0.4661	0.5000	0.2331
3	Coastal environmental pollution	0.1608	0.5000	0.0804
4	Transportation risks	0.0958	0.5000	0.0479
5	Risk of damage to machinery and equipment	0.1543	0.2500	0.0386
6	Food safety risks	0.4474	0.2500	0.1118
7	Risk of occupational accidents	0.0902	0.2500	0.0225
8	Risk of experienced workers quitting	0.0553	0.2500	0.0138
9	Production is delayed	0.2529	0.2500	0.0632
10	Storage risk	0.6667	0.2500	0.1667
11	Inventory Management Risks	0.3333	0.2500	0.0833

4.4 Level of impact of risk criteria

Table 18 shows the Impact Level of the risk criteria.

Table 18. Level of impact of risk criteria

No.	Risk Criteria	Impact
1	Sourcing of raw materials	3.2774
2	Weather Risk	5.0000
3	Coastal environmental pollution	2.2144
4	Transportation risks	1.6219
5	Risk of damage to machinery and equipment	1.4516
6	Food safety risks	2.7883
7	Risk of occupational accidents	1.1591
8	Risk of experienced workers quitting	1.0000
9	Production is delayed	1.9014
10	Storage risk	3.7886
11	Inventory Management Risks	2.2682

4.5 Frequency of occurrence of risk criteria

Table 19 shows the frequency of occurrence of risk criteria.

Table 19. Frequency of occurrence of risk criteria

No.	Risk Criteria	Frequency of Occurrence
1	Sourcing of raw materials	0.37
2	Weather Risk	0.72
3	Coastal environmental pollution	0.93
4	Transportation risks	0.25
5	Risk of damage to machinery and equipment	0.35
6	Food safety risks	0.88
7	Risk of occupational accidents	0.23
8	Risk of experienced workers quitting	0.38
9	Production is delayed	0.90
10	Storage risk	0.70
11	Inventory Management Risks	0.53

4.6 Risk score of risk criteria

Table 20 shows the Risk Score values of the risk criteria.

Table 20. Risk score of risk criteria

No.	Risk Criteria	RS
1	Sourcing of raw materials	1.2017
2	Weather Risk	3.5833
3	Coastal environmental pollution	2.0668
4	Transportation risks	0.4055
5	Risk of damage to machinery and equipment	0.5080
6	Food safety risks	2.4630
7	Risk of occupational accidents	0.2705
8	Risk of experienced workers quitting	0.3833
9	Production is delayed	1.7112
10	Storage risk	2.6520
11	Inventory Management Risks	1.2097

4.7 Pareto chart and risk prioritization

Table 21 shows the values associated with the risk score in the Pareto analysis. Figures 3 and 4, respectively, show the risk score values of the criteria before and after Pareto analysis.

Table 21. Values related to risk score in pareto analysis

Risk Criteria	RS Gradually Decreases	RS Accumulate	RS Acumulated (%)
PrPR2	3.5833	3.5833	22
PoPR1	2.6520	6.2354	38
RIP2	2.4630	8.6984	53
PrPR3	2.0668	10.7652	65
RIP5	1.7112	12.4764	76
PoPR2	1.2097	13.6861	83
PrPR1	1.2017	14.8878	90
RIP1	0.5080	15.3959	94
PrPR4	0.4055	15.8014	96
RIP4	0.3833	16.1847	98
RIP3	0.2705	16.4552	100

The results of the risk score analysis according to the Pareto chart (Figure 4) show that 80% of the risks that occur and affect salt production activities are concentrated in 5 risks (from 11 identified risks), presented in Table 22.

Table 22. List of risks that need to be addressed first

No.	Symbol	Risk Criteria	RS
1	PrPR2	Weather Risk	3.5833
2	PoPR1	Storage risk	2.6520
3	RIP2	Food safety risks	2.4630
4	PrPR3	Coastal environmental pollution	2.0668
5	RIP5	Production is delayed	1.7112

According to Table 22, the top priority risk to be addressed is weather risk (PrPR2), with a risk score value of 3.5833. Analyses at both the macro and micro levels reveal that weather has a big influence on how businesses operate. Ongoing climate change has made unusual weather events a reality. Unpredictability and variety in the weather have become commonplace. Many nations' governments are being compelled to enact adaptation measures in order to fight climate change as a result of the growing frequency and magnitude of extreme weather events. Since the majority of its operations are conducted outside, agriculture is one of the sectors most susceptible to the adverse effects of weather, aside from the energy and construction sectors [31]. Next is Storage Risk (PoPR1), with a risk score value of 2.6520. Storage is an extremely important job after the production process to ensure the quality of the finished product when it reaches consumers; this is something that manufacturing enterprises need to pay attention to. Improper storage or lack of storage equipment can affect the quality of the goods. Next is Food Safety Risk (RIP2), with a risk score value of 2.4630. One of the main concerns for the global food chain is food safety risk, which is the existence of undesired or unknown physical, chemical, or biological contaminants on the product label [40]. Food safety is a daily worry for everyone and a significant public health issue. Humans can be harmed by contaminated food, which raises the need for insurance, medical services, and government spending on public health and other social expenses. Finally, contaminated food can transmit diseases and even cause death [41]. Next is the coastal environmental pollution risk (PrPR3), with a risk score value of 2.0668. Coastal environmental pollution can change the physical, chemical, and biological state of the sea and coastal waters, posing a threat to natural aquatic animals, marine ecosystems, and marine and coastal industries, such as fishing/aquaculture, tourism, and many other activities, including salt production. Contaminated coastal seawater can change the quality of seawater entering salt fields, thereby affecting the quality of raw salt. Last on the list of risks that need to be addressed is Production Delay Risk (RIP5), with a risk score of 1.7112. Production delay risks can arise from the source of raw materials or from the size of the order. If raw materials are scarce or the order size is small, due to a sudden drop in demand that affects the production plan, they can cause production delays [33].

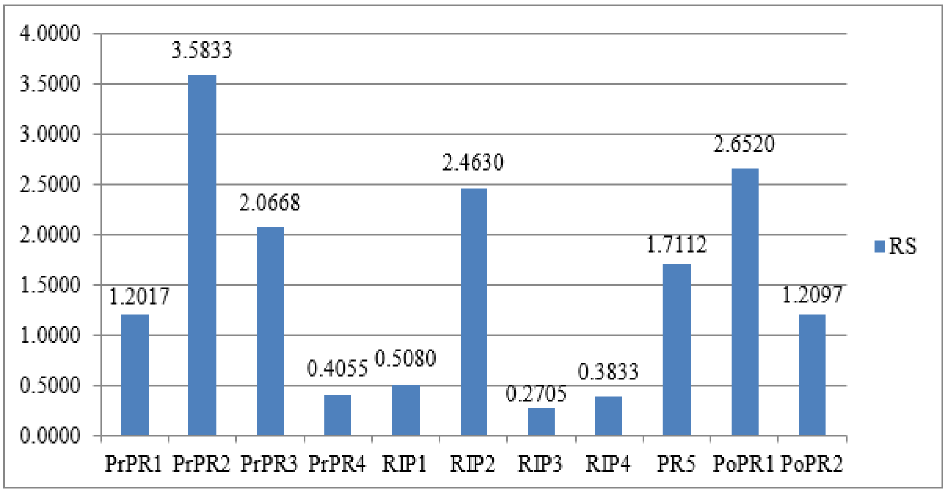

Figure 3. Risk score of risks in salt production activities

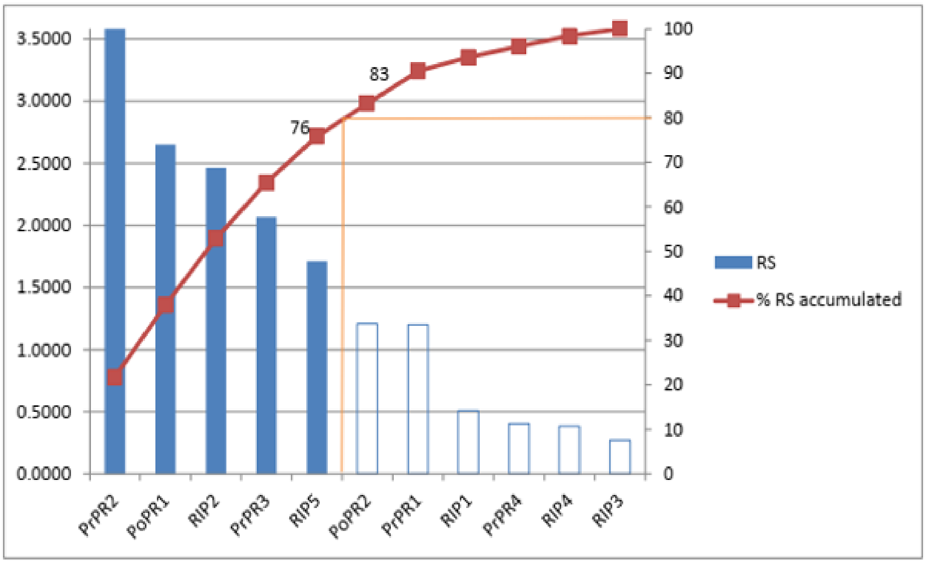

Figure 4. Pareto analysis risk score of risks in salt production operations

The remaining six risks include PoPR2, PrPR1, RIP1, PrPR4, RIP4, and RIP3, with risk score indexes ranging from 1.2097 to 0.2705, respectively. Although this group of risks is not in the top 5 risks, we cannot ignore it because, if analyzed carefully, each risk also shows its relative impact on the overall production activities.

5. CONCLUSION AND IMPLICATION

5.1 Conclusion

The production activities of salt processing enterprises in Central Vietnam are facing different types of risks. A total of 11 risk criteria were finalized using a systematic literature review with expert input. The authors used a multi-criteria decision-making method, called AHP, to determine the overall weight of the risk criteria, then performed linear interpolation to determine the impact level of the risk criteria, and then calculated the risk score index by calculating the product of the impact level and the frequency of occurrence of the risk criteria. Finally, the authors drew a Pareto chart to find out the priority risks that need to be addressed.

The study's findings demonstrated that the top 5 risk criteria that need to be addressed include weather risk (PrPR2), with a risk score value of 3.5833; storage risk (PoPR1), with a risk score value of 2.6520; food safety risk (RIP2), with a risk score value of 2.4630; coastal environmental pollution risk (PrPR3), with a risk score value of 2.0668; and finally, delayed production risk (RIP5), with a risk score value of 1.7112.

The study has comprehensively synthesized risks in the production activities of salt processing enterprises in the Central region of Vietnam. The study has shown that the AHP method can be applied in combination with the risk score index and Pareto analysis to prioritize risks. The results of this study can also help managers make decisions on choosing priority risk treatment in order to increase the efficiency of the enterprise's production activities.

5.2 Implications

From the above analysis results, with 5 risks that need to be prioritized, the study offers some corresponding management implications to improve the production efficiency of salt processing enterprises in Central Vietnam as follows:

Regarding weather risks: Weather is a natural factor that is very difficult to control. However, if businesses want to avoid this risk, the issue to note is the reserve of raw materials. For the weather in Central Vietnam, storms are very unusual; the prolonged rainy season will affect the salt fields, so it is necessary to monitor the daily weather forecast and take advantage of mild weather to be more favorable in creating raw salt and storing raw salt.

Regarding storage risks: Enterprises need to update new preservation equipment and technology, both saving costs and increasing the efficiency of preservation work such as CAS equipment (Cells Alive System), preservation by irradiation method, etc. Conditions of light and temperature need to be considered when preserving finished products from salt.

Regarding food safety risks: Enterprises producing and processing food need to strictly comply with the regulations of competent authorities on food production, processing, and trading according to the food safety law. The place of food production and processing must ensure that the environment is always clean and dry. The use of additives and preservatives must be in the correct dosage and on the list permitted by the health agency.

Regarding the risk of coastal environmental pollution: Enterprises and salt farmers need to regularly clean the area around the salt fields and check the quality of seawater in the coastal areas approaching the salt fields. In the long term, it is necessary to develop a plan for planning areas, clusters, industrial points, and craft villages specifically for the salt industry.

Regarding the risk of delayed production: Enterprises need to establish a reasonable production plan, strengthen forecasting of demand for Salt and Salt products, and have a plan to reserve raw Salt sources in accordance with market demand.

5.3 Limitations

Regarding the limitations of this study, the experts' evaluation may be biased towards their field of expertise and their level and seniority. Furthermore, with the AHP method, risk analysis is performed using relative priority weights. Therefore, caution should be exercised when constructing a comparison matrix of risk criteria. The study has considered the impact of each risk criterion on the overall production activities but has not considered the interaction of risks with each other, which is also a limitation of the AHP method.

In this study, the author applied the AHP, combined with the Risk Score Index and Pareto analysis, to prioritize risk factors. Future studies by other scholars may combine AHP with one or two other methods to solve risk prioritization problems. The study was conducted at salt production and processing enterprises in Central Vietnam, and the subject was risks in salt production activities, so future studies can be conducted in a different scope or with another research subject, such as risks in rice production activities, risks in steel production activities, risks in cement production activities, etc.

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