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Risk Management Analysis in Tobacco Supply Chain Using the House of Risk Method

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Abstract

Many risks affect the smooth flow of the supply chain, thereby necessitating numerous efforts to improve supply chain management by preventing and resolving these occurrences. Therefore, the purpose of this research was to determine the sources of possible and priority risks in the tobacco supply chain in Probolinggo Regency and design appropriate priority management strategies. This research investigated the flow of the tobacco supply chain and identified various possible risks using the Failure Modes and Effect Analysis (FMEA) method, which analyzes the impact or severity and chance of occurrence. A risk event was conducted in the plan and source process to determine the type of risk and identify the priority agents that can be reduced by the House of risk (HOR) approach. Subsequently, this research obtained 11 risk events and 20 agents, including 4 priorities for handling, alongside 4 coping strategies designed to address and reduce possible sources of risk in the tobacco supply chain

Keywords: Supply Chain, Tobacco, Risk, FMEA, HOR

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1. Introduction

Indonesia is an agrarian state in which most of its population live in villages and adopt livelihoods as farmers with big and varying consumer markets. Meanwhile, a significant percentage of the adult males in the country, approximately 60% of the total population of 240 million, are smokers (Tamboto & Manongko, 2019).

Tobacco is a seasonal farming plantation commodity, rather than food, is consumed for leisure filling or "pleasure," and is the major raw material of cigarettes and cigars. The substance can be chewed, and its rich subsidiary metabolites also act as pesticides and medicinal raw materials.

A factor that influences tobacco production in the supply chain of farming commodities is the harvested area. This is visible from the data accumulated by the Central Statistics Agency (BPS), which reported a total of 9,800.05 tons of produced tobacco at the Probolinggo District in 2018. The high production at this district is influenced by its geography, as the land has suitable substance to support tobacco cultivation. However, the large amounts provided are inconsistent with the low selling price of farmers. The reduced sale value is caused by climate change, such as rain, and green caterpillar pests, which eat the tobacco leaves and ruin the plants. Consequently, it reduces the quality and purchase prices of the middlemen. This has been proven by previous studies to acknowledge the mitigation risk of the tobacco supply chain at Probolinggo District (BPS, 2020).

Meanwhile, the House of Risk (HOR) model can be used to identify and measure potential risks in the tobacco supply chain at Probolinggo District (Pujawan & Geraldin, 2009b). It is a modification of the Failure Mode and Effects Analysis (FMEA) model, used to measure risk quantitatively (Vazdani et al., 2017). Meanwhile, the House of Quality (HOQ) model prioritizes the risk agents that should be handled first and chooses the most effective action to reduce the potential impacts of risk agents. This method consists of two phases, namely risk identification and cause, which constitute Phase 1, and risk management, which forms Phase 2. The first phase involves determining the dominant risk cause by calculating the ARP value. Conversely, Phase 2 entails identifying the dominant risk management strategy,

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alongside considering the level of convenience of the strategic implementation and the correlation between strategy and risk cause.

Therefore, the objectives of this research are to (1) analyze the priority risks and the source, which are the main priority of the tobacco supply chain process at Probolinggo District, and (2) acknowledge and determine the risk mitigation priority from the analysis result to minimize the disturbances of the supply chain process.

2. Research Method

2.1. Research Location

Probolinggo District was deliberately selected as the research location because it is the most dominant tobacco producer in East Java, considering its large production, productivity, and distribution.

2.2. Sampling Determination Method

Supply chain analysis requires key information as an entry point. This research used a purposive method to obtain information, which, according to (Sugiyono, 2010), is a data retrieval technique with certain considerations. The acquisition of important information will allow an intensive evaluation of the supply chain from tobacco farmers to the consumer. Subsequently, the snowball sampling, described by (Joko Subagyo, 2006) as retrieval technique developed with the help of key information, was employed. Snowball sampling is defined as a source of retrieval in which there is initially few or incomplete data, leading to the search for additional sources. The entry point at this research was a tobacco farmer from Probolinggo District.

2.3. Data Analysis Method

1) Supply Chain Flow Model

Supply chains (SCs) processes are an important part of the daily enterprises of many professional and personal activities in modern life, and they are highly significant for global development (Garay-Rondero et al., 2020). The descriptive analysis method was used to acknowledge this supply chain model, including the structure, resources, and business process from farmer up to the consumer.

2) Risk Identification and Risk Cause Phase

The next step involved analyzing potential risks, the reason, the location, and the method of the occurrence in that area (Deny, 2012).

Generally, a risk is defined in this research as the uncertainty of an incident that brings adverse impacts to tobacco farmers. Conducting an interview with tobacco farmers as the respondents is necessary to identify risks and their causes. The interview was expected to gain several risks and causes that affect the productivity and performance of tobacco farmers in the Probolinggo District.

3) Risk Assessment

The next step was the risk assessment phase, the regulatory risk assessment process is not bogged down (Council, 2009) which is a process to assess the severity level and probability of a risk incident. It was achieved using determining three factors, including the severity level of the risk incident, the probability of risk incident or agent, and the correlation value between risk incident and agent. These three factors are necessary for calculating Aggregate Risk Potential (ARP) value, which is a benchmark to manage cause risks. Subsequently, the cause risks with the highest ARP should be prioritized by performing mitigation actions.

4) Risk Analysis by House of Risk

Identifying the risk potential is the next step in the management. Risk identification entails determining potential risks during operations. Although some of these risks occur internally, some external factors can cause them to become operational. Therefore, information quality resulting from risk identification determines the quality of the analysis result. Risk analysis generally involves the development of quantitative estimations based on evaluation and mathematical techniques. It involves tools, techniques, and methods to increase and facilitate the analysis process. Meanwhile, this research employed a survey and interview process for risk identification.

The risk analysis process was performed using the House of Risk (HOR) method developed by (Pujawan & Geraldin, 2009a). It was selected to determine the risk agent that should be prioritized to obtain preventive treatment. The agents were ranked based on the amount of ARP value for each risk. This allowed the selection of some top-ranked agents considered to potentially induce risk incidents. The HOR1 and HOR2 models were used in this research. HOR1 was employed to determine the agent that should be prioritized to obtain preventive treatment. Conversely, HOR2 was used to determine the dominant risk management strategy by considering the level of convenience of the strategy implementation, alongside the correlation between strategy and risk cause.

3. Result and Discussion

3.1. East Java Tobacco

One of the factors that influence tobacco production in farming commodities supply chains is the harvested area. Table 2.1 describes the harvested area and tobacco production of Indonesia in 2018 obtained from 15 provinces. East Java is one of the contributors, and according to the Director-General of Plantation Data in 2019, the province holds the first position as a tobacco producer by supplying 85,083 tons from a harvested area of 105,595 Ha (BPS, 2020).

As shown in Table 1, the largest production of Indonesian tobacco was at East Java Province with a total of 85,053 tons. The large harvest, which is due to the province's geography, contradicts the tobacco selling price of farmers. Hence, good management is required of each member of the supply chain flow to ensure the prices of each perpetrator become fairer.

Table 1. Harvested area and production in Indonesia in 2018 (BPS, 2020)

No	Province	Area (Ha)	Production (Ton)
1	Aceh	1,645	2,000
2	North Sumatera	1,221	1,145
3	West Sumatera	585	712
4	Riau	-	-
5	Riau Islands	-	-
6	Jambi	531	331
7	South Sumatera	235	156
8	Bangka Belitung Islands	-	-
9	Bengkulu	-	-
10	Lampung	840	948
11	DKI Jakarta	-	-
12	West Java	8,925	8,196
13	Banten	-	-
14	Central Java	42,200	34,006
15	Yogyakarta	1,750	1,500
16	East Java	105,595	85,058
17	Bali	721	1,275
18	West Nusa Tenggara	33,859	44,943
19	East Nusa Tenggara	1,809	1,025
20	West Kalimantan	-	-
21	Central Kalimantan	-	-
22	South Kalimantan	-	-
23	East Kalimantan	-	-
24	North Kalimantan	-	-
25	North Sulawesi	-	-
26	Gorontalo	-	-
27	Central Sulawesi	123	70
28	South Sulawesi	2,673	1,822
29	West Sulawesi	-	-
30	Southeast Sulawesi	-	-

No	**Province**	**Area (Ha)**	**Production (Ton)**
31	Maluku	-	-
32	North Maluku	-	-
33	Papua	-	-
34	West Papua	-	-
	Indonesia	**202,712**	**183,155**

3.2. Chain Structure of Tobacco Supply Chain

The structure shows the activities of related parties in the supply chain. It consists of links of tobacco supply chain members in Probolinggo, such as farmers, buyers, traders, collectors, and factories.

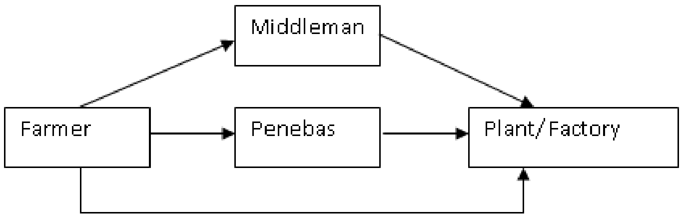

Figure 1. Tobacco Supply Chain

3.3. Risk Identification

The previous explanations display some activities that occur in the tobacco supply chain flow in Probolinggo District. Subsequently, the risk identification was performed using the Failure Mode of Effect Analysis (FMEA) approach. According to (Vazdani et al., 2017), the reason is that FMEA is a technique for analysing the cause of the potential disturbance, alongside the probability and prevention of occurrences. The FMEA concept in this research employed only 2 variables, namely the probability of occurrence, and risk impact or severity. The values of these variables were measured by interviewing experts in the field. These experts were selected based on interview results with farmers, middlemen, or buyers, and factories that supervise all activities in the tobacco supply chain.

Furthermore, the interview results indicated 11 risks in the tobacco supply chain and their severity values are presented in Table 2.

Table 2. Risk Event Identification Result

Code	Actor	Risk Event	Severity
E1	Farmer	Change of Harvest Time	5
E2		Crop Failure	10
E3		Low priced	9
E4	Middlemen	Imprecise Grade Tobacco	7
E5		Lost Volume of Tobacco during transportation to factory	8
E6		Uncertain open warehouse hours	5
E7		Loading Queue of Tobacco at Factory	5
E8		Delayed materials from warehouse	9
E9	Factory	Error in stockpiling the tobacco	10
E10		Worker accident	8
E 11		Defective Machine	7

After the risk event and severity value are determined, the cause should be identified. Table 1 shows the measurement result of the severity value of each risk event obtained from expert opinions. Following the acknowledgment of each risk category or agent, risk management strategies were designed using the House of Risk. Table 2 shows a list of the risk agents of each event and the measurement value of each occurrence.

The table shows 2 risk agents or sources as well as their occurrence values. Subsequently, the occurrence values of the risk agents and the severity of the events will become input for the House of Risk phase 1. The correlation value between the risk events and agents rated by experts in Table 4 was also used.

Table 2. Risk Agent Identification

Code	Actors	Risk Agent	Occurance
A1	Farmer	Tobacco leaves do not ripen in time	3
A2		Workers are unable to harvest	2
A3		Bad Climate Change	5
A4		Caterpillar pests	7
A5		Degrading Market Value	4
A6		Low Quality of Tobacco	2
A7	Middleman	Low Quality of Tobacco Packing	3
A8		Street heading to Factory is damaged	6
A9		Uncertainty open warehouse hours	2
A10		Many middlemen / buyers submit tobacco to the Factory	4
A11		Late Departure to Factory	2
A12		Malfunction of Tobacco trucks	2
A13		Bad street condition	3
A14	Factory	Depreciation of Tobacco materials	6
A15		Materials mixed up with strange items	6
A16		Operator Negligence	4
A17		Lack of Practice K3	3
A18		No personal protective equipment	2
A19		Occurrences outside Production	2
A20		Non-Maintenance of Tools/Machines	4

3.4. House of Risk Phase 1

3.4.1. Calculation of Aggregate Risk Potential (ARP)

The calculation of the Aggregate Risk Potential (ARP) aims to determine the priority in managing risk agents. These agents are then sorted from the highest to lowest ARP value. The calculation of the Aggregate Risk Potential (ARP) is obtained using the formula below (Pujawan & Geraldin, 2009b):

$$ARPj = Oj \sum Si\ Rij \qquad (1)$$

Description:

ARPj = Aggregate Risk Potential
Oj = Occurrence level of risk
Si = Severity level of risk
Rij = Level of connection between risk agents (j) and risks (i)

This risk agent has the highest value of 1020 and is ranked first, showing that it requires the main priority in handling than others. The House of Risk Phase 1 for this research is shown in Table 4.

3.4.2. HOR 1 Table

The HOR Phase 1 table displays the final stage of the risk identification. It shows that the severity value of the risk event, the occurrence value of the source, and their correlation are gained from the interview with the company((Pujawan & Geraldin, 2009b). Meanwhile, the highest Aggregate Risk Potential (ARP) value will be prioritized to conduct risk mitigation.

3.4.3. Risk Evaluation

The final HOR Phase 1 stage involved a Pareto diagram of the Aggregate Risk Potential (ARP) value of the risk agent. This diagram showed the risk agent whose management must be prioritized. This risk evaluation uses the biggest value principal for each chain of the Pareto diagram, meaning the overall improvement of other risk agents is expected to be influenced by handling the prioritized risk agent. (Pujawan & Geraldin, 2009b).

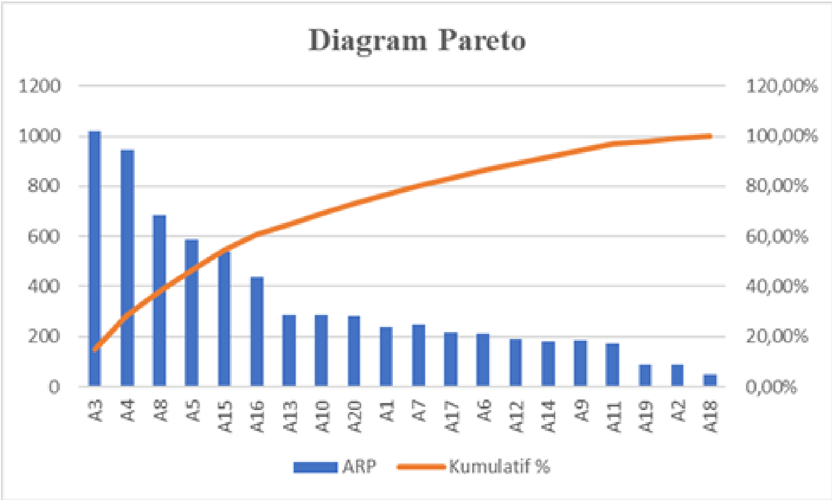

Figure 2. Pareto Diagram

In this research, 4 risk agents were evaluated to handle the management strategy planning expected to influence the improvement of 16 other agents. The risk agents were selected based on previous experiences on mitigation risks as well as because they had the highest level of occurrences on each chain and to ensure more focus was placed on implementing the management strategies.

Table 3. HOR Phase 1

	Risk Agent																				
Risk Event	Farmer				Middleman/Penebas										Factory						Severty
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	
E1	9	9	9	3	3	3	0	0	3	0	0	1	0	0	0	0	0	0	0	0	5
E2	0	0	9	9	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
E3	3	0	9	3	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
E4	3	0	1	3	3	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
E5	0	0	1	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	8
E6	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	5
E7	0	0	0	0	0	0	0	3	9	9	9	3	3	0	0	0	0	0	0	0	5
E8	0	0	3	0	0	0	0	3	3	3	3	9	9	0	0	0	0	0	0	0	9
E9	0	0	0	0	0	0	1	0	0	0	0	0	0	3	9	3	0	0	0	0	10
E10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	3	3	1	8
E11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	9	7
Occurrence	3	2	5	7	4	2	3	6	2	4	2	2	3	6	6	4	3	2	2	4	
ARP	279	90	1290	1071	540	230	246	684	204	288	174	202	288	180	588	436	216	48	90	284	
Ranking	10	19	1	2	5	13	11	3	16	8	17	14	7	15	4	6	12	20	18	9	

3.4.4. House of Risk Phase 2

This phase entails the planning of mitigation actions, defined as procedures to reduce the impact of risk agents before the appearance of incidents. Alternative risk mitigation was achieved by brainstorming with the company (Bayu, 2014). During the interview, the actions on managing the risk agents by considering the level of the severity and effectiveness were discussed with the company (Agiwal & Mohtadi, 2008).

a) Strategic Mitigation Planning

The Aggregate Risk Potential (ARP) values gained from the HOR Phase 1 result show some risk agents that will be mitigated. These agents generated the highest ARP value on every chain. The final output of the HOR phase 1 Pareto diagram shows the priority ranking of the risk agents based on the ARP values. Table 4 shows the risk agents that will be mitigated.

After listing the priority risk agents known, the dominant risks were mapped using the Probability Impact Matrix model. This was aimed at observing the risk condition before management. The position of the dominant risk agent is shown on the figure 3.

The risk map shows that the agents coded A3 and A4 were placed at critical risk positions and required immediate management. Conversely, agents A8 and A15 codes were ranked as medium risk, meaning they needed regular management and an effective control strategy. The map confirms that the management strategy of priority risk agents needs to ensure the business process in the supply chain functions optimally.

Table 4. Risk Agent Ranking Based on ARP Value

ARP Rangking	Code	Risk Agent	ARP Value	Oj	Si
1	A3	Bad Climate	1290	5	8
2	A4	Catterpilar Pest	1071	7	8
3	A8	Bad road condition towards factory	684	6	7
4	A15	Materials mixed up with strange substances	588	6	7

	Severity				
Occurance	Very Low	Low	Moderate	High	Very High
Very High					
High					
Moderate				A3	
Low				A4	
Very Low				A8 A 15	

Figure 3. The Risk Mapping After Identification

House of Risk Phase 2 is a follow-up on Phase 1 and involves the mitigation of the dominant risk result gained from HOR 1. Phase 2 is a risk mitigation strategy determined by focus group discussions with experts from each supply chain.

From the ARP value on Table .4 and map risk displayed in Figure 3, focus group discussions were conducted with the farmers, buyers, and factories to determine the best management strategy for minimizing the occurrence of risk agents. As shown in Table 5 below, the outcome of this discussion with the company identified management strategies for 16 risks.

Table 5. Risk Agent Management Strategy

No	Risk Agent	Mitigation Strategies
1	Bad Climate	Using good quality of seeds
2	Caterpillar pest,	Using pesticide and sustainable agriculture training
3	Bad road condition towards factory	using alternative roads route
4	Materials mixed up with strange substances	Inspection materials occasionaly.

b) Calculation of the Total Effectiveness and Result Assessment of the Degree of Difficulty

The second step was the calculation of the total effectiveness to measure the efficacy of the mitigation action. It was estimated by multiplying the correlation value between the risk agent (j) and preventive action (k). The effectiveness was calculated from the risk management proposed, using the formula (Bayu, 2014):

$$TEk = \sum ARPj \times Ejk \quad (2)$$

Description:

TEk = Total Effectiveness of each mitigation strategy
ARPj = Aggregate Risk Potential
Ejk = Connection between each preventive action of each risk agent

Following the calculation of the total effectiveness, the degree of difficulty was assessed by an expert. The purpose was to evaluate the severity level of the management strategy to be conducted.

c) Calculation of the Ratio of Effectiveness to Difficulty

The effectiveness to difficulty ratio was estimated by the dividing Total Effectiveness value (TEk) with the difficulty level of an action. The importance of this ratio was to determine the priority ranking of all actions, with a calculation sample below (Bayu, 2014).

$$ETDk = \frac{TEk}{Dk} \quad (3)$$

Description:

ETDk = Total Effectiveness to Difficulty ratio
Tek = Total Effectiveness
Dk = Difficulty level of conducting an action

The results of the total effectiveness to difficulty ratios can be seen in Table 6, which presents HOR Phase 2. After the ratios were obtained from all management strategy plans, the management strategy plans for the priority risk were proposed based on the highest to lowest effectiveness to difficulty values.

3.4.5. HOR Phase 2

The House of Risk Phase 2 calculation indicated the risk management sequence based on ETD values with the highest as the priority. After obtaining the management priority based on the effectiveness level of the implementation, an assessment of the severity and occurrence level was performed by an expert based on the risk agents identified during the management strategy. This assessment was aimed at remapping the risk condition made by the management priority strategy and was conducted by experts through focus group discussions. After conducting the priority planning, the company risks that were in the high category, highlighted in red area, can be managed and improved (Scandizzo, 2005). This process was followed by figure 4, a risk map drawn after implementing the management planning.

	Severity				
Occurance	Very Low	Low	Moderate	High	Very High
Very High					
High					
Moderate		A3			
Low		A4			
Very Low		A8	A 15		

Figure 4. Risk Map Image After the Management Implementation Planning

The figure 4 shows the risk map after the priority management planning. Initially, the risks coded A3 and A4 were in the red area, meaning they were high. Conversely, A8 and A15 were in the yellow area, signifying the medium category. After implementing the priority management planning, A4, A8, and A15 moved to the green area until only one high risk was left. The green area denotes risks in the low category, meaning only short surveillance and sufficient normal control are required.

One of the mitigation strategies implemented is The Research Center for Sweeteners and Fibers (Balittas) Malang and the UPT for Supervision and Certification of the Quality of Plantation Seeds in East Java Province have to provide training on the application of tobacco cultivation according to Good Agricultural Practices (GAP) from land management, seed selection, good fertilization, post-harvest maintenance and climate anticipation for farmers in Probolinggo. SLPHT (Integrated Pest Control Field School) ensures superior seeds in the form of certified seeds to improve the quality of tobacco.

4. Conclusion

The conclusions of the data processing and discussion analysis results were seen as follows:

a. The tobacco supply chain management at Probolinggo District comprises 1) Farmer → Middleman → Factory. 2) Farmer → Buyer → Factory. 3) Farmer → Factory.

b. There were 11 tobacco supply chain risk events and 20 identified risk agents. From the House of Risk Phase 1 processing and Pareto diagram, the 4 risk agents became management priorities. They were bad climate change, caterpillar pests, bad conditions of the roads leading to the factory, and the mix-up of materials with strange substances.

c. After the House of risk Phase 2 assessment on the tobacco supply chain process, 4 risk management strategies were obtained. These were planting quality seeds, pesticide sprinkling, using alternative roads or routes, and checking materials occasionally.

References

Agiwal, S., & Mohtadi, H. (2008). Risk mitigating strategies in the food supply chain. *The American Agricultural Economics Association Annual Meeting*, *May 2014*, 1–30.

Bayu. (2014). *PENGANTAR MANAJEMEN RISIKO*. 77.

BPS. (2020). *BPS Kabupaten Probolinggo*.

Council, N. R. (2009). *Science and decisions: advancing risk assessment*.

Deny, P. et al. (2012). Analisa Rantai Pada Agribisnis Ayam Pedaging Dengan Pendekatan Analisa Rantai Nilai Dan Analisa Nilai Tambah. *Jurnal Teknik Industri, Universitas WR Supratman.*

Garay-Rondero, C. L., Martinez-Flores, J. L., Smith, N. R., Morales, S. O. C., & Aldrette-Malacara, A. (2020). Digital supply chain model in Industry 4.0. *Journal of Manufacturing Technology Management*.

Joko Subagyo, P. (2006). Metode Penelitian Dalam Teori Dan Praktek. *Rineka Cipta. Jakarta*.

Pujawan, I. N., & Geraldin, L. H. (2009a). House of risk: a model for proactive supply chain risk management. *Business Process Management Journal*.

Pujawan, I. N., & Geraldin, L. H. (2009b). House of risk: A model for proactive supply chain risk management. *Business Process Management Journal*, *15*(6), 953–967. https://doi.org/10.1108/14637150911003801

Scandizzo, S. (2005). Risk mapping and Key Risk Indicators in Operational Risk management. *Economic Notes*, *34*(2), 231–256. https://doi.org/10.1111/j.0391-5026.2005.00150.x

Sugiyono. (2010). *Metode Penelitian Kuantitaf Kualitatif dan RND*. Alfabeta, 44-50.

Tamboto, H. J. D., & Manongko, A. A. C. (2019). *Model Pengentasan Kemiskinan Masyarakat Pesisir Berbasis Literasi Ekonomi dan Modal Sosial*. Makaria Waya.

Vazdani, S., Sabzghabaei, Gh., Dashti, S., Cheraghi, M., Alizadeh, R., & Hemmati, A. (2017). Fmea Techniques Used in Environmental Risk Assessment. *Environment & Ecosystem Science*, *1*(2), 16–18. https://doi.org/10.26480/ees.02.2017.16.18