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Risk Analysis of Post-Disaster Logistics Distribution Failure

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ABSTRACT

In conducting logistical activities of disaster relief in natural disaster management. it is often not possible to implement as it should. and there are always potential risks that arise. One of the problems faced is the delayed distribution of post-disaster logistics. Therefore. risk management is necessary so that disaster relief logistics activities can run well. In addition. there is a need for a risk mitigation strategy to mitigate potential risks in the post-disaster logistics distribution process. The study aims to identify potential risks to post-disaster logistics distribution activities and find out which risk management strategies are a priority to address immediately. Failure Mode and Effect Analysis (FMEA) is a systematic approach to identifying failures and giving a value or score to each risk. From the results of the study. 32 potential risks occurred. As a result. 13 risks were identified with RPN values above critical point values. Thus. 13 were obtained as priority management risks. where the risks with the top 3 RNA values are Disruption of the post-earthquake telephone network Difficulty coordination of the logistics team with a rating of 25.98. Long logistic delivery travel time with a value of 21.86. and Condition of the vehicle used is not good with a score of 21.66. Thus. for 13 of these risks. mitigation is carried out for treatment priorities. Risk management strategies are applied to risks that have RPN values above critical values to minimize the impact.

Keywords: *Risk Process Distribution Logistics; Risk Management; FMEA Methods.*

INTRODUCTION

Indonesia is one of the countries that has a high potential for natural disasters. such as volcanic eruptions. earthquakes. landslides. floods. tsunamis. and many other events. The occurrence of natural disasters can cause human losses. both material and immaterial losses. Indonesia has high vulnerability and disaster potential in terms of several aspects. Aspects that can affect the scope of disaster in Indonesia are Geographical. Climatological. Geological. and Socio-Demographic [1].

Padang City is one of the cities located on the west coast of Sumatra. which is vulnerable to natural disasters such as earthquakes and tsunamis. Padang City also has a vulnerability problem to tsunami disasters. The coastal area of Padang city extends about 72 km and the time span between tsunami events is quite short. The existence of natural disasters that result in many victims displaced and damage to public facilities. the government is responsible for the implementation of disaster management which includes pre-disaster. during disaster. and post-disaster. The government has the authority and purpose to protect the community by making appropriate prevention and handling measures so that disasters that occur can be resolved. one of which is by creating institutions. agencies or organisations that are given more authority by

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the government in an effort to cope with the occurrence of disasters. One of the most important factors in disaster management is the availability of adequate road access. However, in Padang City itself there are several obstacles in building a road network that is resistant to natural disasters. especially for evacuating residents and distributing logistics. These constraints include topography and soil conditions that do not allow the construction of straight and wide roads. The following table 1.1 is the disaster risk index per district/city in West Sumatra Province.

Table 1. Risk Index Values of West Sumatra Province from 2015 to 2022

No	REGENCY/CITY	2015	2016	2017	2018	2019	2020	2021	2022
1	PASAMAN BARAT	203.20	203.20	203.20	203.20	203.20	203.20	203.20	203.20
2	KEPULAUAN MENTAWAI	197.20	197.20	197.20	197.20	197.20	197.20	197.20	197.20
3	AGAM	209.20	209.20	209.20	209.20	209.20	209.20	193.52	193.52
4	KOTA PADANG	209.20	209.20	191.60	191.60	169.92	169.92	181.70	179.03
5	PASAMAN	178.00	178.00	178.00	178.00	178.00	178.00	176.80	176.80
6	KOTA PARIAMAN	171.20	171.20	171.20	171.20	171.20	171.20	171.20	157.28
7	PADANG PARIAMAN	196.80	196.80	184.11	184.11	180.72	167.21	156.73	156.73
8	PESISIR SELATAN	189.60	189.60	189.60	189.60	189.60	189.60	169.42	152.96
9	DHAMASRAYA	143.20	143.20	143.20	143.20	143.20	143.20	137.69	137.69
10	SOLOK	137.20	137.20	137.20	137.20	137.20	137.20	137.20	137.20
11	SOLOK SELATAN	137.20	137.20	137.20	137.20	137.20	137.20	137.20	137.20
12	KOTA BUKITTINGGI	130.00	130.00	130.00	130.00	130.00	130.00	130.00	128.01
13	TANAH DATAR	125.20	125.20	125.20	125.20	125.20	125.20	125.20	125.20
14	LIMA PULUH KOTA	119.20	119.20	119.20	119.20	119.20	119.20	119.20	119.20
15	KOTA SOLOK	125.20	125.20	125.20	125.20	125.20	125.20	125.20	115.82
16	KOTA PADANG PANJANG	113.20	113.20	113.20	113.20	113.20	113.20	113.20	113.20
17	SIJUNJUNG	107.20	107.20	107.20	107.20	107.20	107.20	107.20	107.20
18	KOTA PAYAKUMBUH	104.80	104.80	104.80	104.80	104.80	104.80	104.80	104.80
19	KOTA SAWAHLUNTO	113.20	113.20	113.20	113.20	113.20	113.20	113.20	101.08

Based on Table 1.1 shows that of the 19 districts/cities in West Sumatra Province. 8 of them have a large risk class which is in the first position in West Sumatra Province which has a large risk. and Padang City is included in the category of a large risk class and is vulnerable to disasters that have a significant impact. BNPB and BPBD are designed for comprehensive disaster management. which is a change from the conventional approach of emergency response to a new perspective. This perspective places equal emphasis on all aspects of disaster management and focuses on risk reduction. According to Presidential Regulation No. 8 of 2008 article 1 paragraph 1. the Regional Disaster Management Agency (BPBD) is a non-departmental government agency that carries out tasks in disaster management in the province or regency or city with guidelines on policies set by the National Disaster Management Agency. The establishment of institutions by the government can guarantee the fulfilment of the rights of communities affected by disasters fairly and in accordance with minimum service standards as stated in Law No. 24 of 2007 concerning disaster management article 6c. Based on these considerations. the efforts that need to be made by the government and local governments are

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to provide protection to the community from the impact of disasters. and to restore conditions from the impact of disasters. including logistical assistance during emergency status. Logistics support must be on time. location. target. quality. quantity. and as needed. The reality is different. when the distribution of aid for victims of natural disasters has not been able to be implemented properly. Various problems still occur such as. unsupportive road conditions and broken bridges so that the logistics distribution process to the disaster site is hampered and delayed. lack of supervision of officers in the process of storing disaster relief. especially consumptive aid that has an expiration date because it has been hoarded for too long so that it reduces the quality of the goods. limited availability of goods at the distributor's warehouse. distribution time. availability of transportation facilities. The uncertainties that arise are some of the many problems that must be overcome in the distribution of disaster relief logistics. Problems that cause losses are called risks.

METHOD

Primary data were obtained through a set questionnaire and interviews (struc-tured) with the Regional Disaster Management Agency (10 respondents) and the De-partment of Transportation (5 Respondents). The data collection technique used was purposive sampling. The purposive sampling technique is a type of non-probability sampling that is most effective when one needs to study a specific cultural domain with experts [2], [3]. Purposive sampling is judgmental. selective. or subjective sam-pling [4], [5]. Purposive sampling is a technique with specific considerations. The consid-erations taken in determining the sample for the purposive sampling technique used in this research are individuals involved in the Logistic Distribu-tion Process [6].

The Failure Mode Effect Analysis Method was used in data analysis. FMEA is a systematic approach for evaluating the potential failure modes in a system [7], [8]. FMEA is a structured method used during a given stage of the system life cycle to understand all probable failure modes and the effects of their occurrences. The risk priority number (RPN) is calculated in FMEA to select more critical failure modes by multiplying three factors: occurrence. detection. and severity [9]. There are several definitions of occurrence. detection. and severity; occurrence is defined by the likeli-hood that the failure mode and its associated cause will be present in the item. detec-tion by the chance that the relevant control method will detect the failure cause or failure mode. and severity by the seriousness of the most severe effect for a given fail-ure mode [10]. Another study [11] explains the occurrence by the chance that a failure cause will occur. detection by the inability to detect a failure cause or the subsequent failure mode. and severity by the severity of a failure mode on the customer.

The questionnaire had five Likert scales describing the condition's occurrence (Scale one (1) is the lowest. describes the risk event as very rare or never happens. and five (5) is the enormous scale. describes the risk event as Always happening or almost always happens); detection (Scale one (1) is the lowest. describes risk events are very difficult to detect. and five (5) is the enormous scale. describes the risk event is very easy to see). and severity (Scale one (1) is the lowest. represents minimal or no impact. and five (5) is the enormous scale. describes the effect is high). The Likert scale measures someone's opinion or several groups as to a phenomenon where the answer to each instrument item has a graduation from low to high [12].

RESULTS AND DISCUSSION

Risk identification is the initial stage in risk management. At this stage. interviews with experts

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are conducted. This stage is carried out by identifying all risks that can affect the achievement of the objectives of each logistics process activity. The following are the results of identifying potential risks in the process of distributing post-disaster logistics assistance.

Table 2. Risk Identification for Logistics Distribution

Process	Aktivity	Risk
Distribution	Reliability and Capacity of transport	a. The capacity of the vehicles used is not sufficient for the logistics distribution process
		b. The condition of the vehicle used is not good
		c. The vehicle used is not capable of travelling on the road to the affected location.
		d. Operational support factors. fuel supply for logistics distribution vehicles is not sufficiently available
	Effectiveness of Routes and infrastructure	a. Roads used in logistics distribution have extreme geometrics
		b. Traffic jams that occur during logistics distribution
		c. Roads or bridges used in logistics distribution are damaged
		d. No alternative route options in logistics distribution
		e. Supporting infrastructure such as harbours and airports are damaged
	Coordination	a. Unclear command during logistics distribution
		b. No common understanding of objectives. procedures. and responsibilities
		c. Lack of engagement and dedication in completing tasks and responsibilities.
		d. Channelling operational standards are not clear
		e. ineffective information between parties involved in logistics distribution
		f. Poor communication between related parties
Responsibility	Security	a. Theft of logistics goods while in transit
		b. Extortion of logistics transport drivers by local thugs
	Social and human aspects	a. There is conflict along the logistics distribution route
		b. Excessive conflicts and different interests of parties in logistics distribution
		c. Poor coordination between relevant parties and the community
		d. Information on community logistics needs is not clearly identified
	Readiness of infrastructure	a. There is insufficient storage space in disaster-affected locations

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		b. Insufficient storage post capacity
Acceptance at Destination	Response Time	a. Slow information on post-disaster logistics distribution.
		b. Complicated logistics distribution procedures cause slow response time.
		c. Long logistics delivery journey time.
	Communication and Technology Infrastructure	a. Phone lines were down after the earthquake. making it difficult to coordinate logistics teams.
		b. Failure of the logistics information system led to difficulties in prioritising shipments
Procurement or acceptance	Logistics and inventory management	a. Insufficient capacity of temporary storage area for logistics items
		b. Information on the classification and labelling of logistics goods is not clear.
		c. Logistics inventory rotation is unclear. FIFO (First-In. First-Out) especially for perishable goods such as food.
		d. Prioritisation in the distribution of post-disaster logistics is unclear

Data Processing

Risk analysis is carried out in order to understand the risk more deeply. The results of the risk analysis obtained will be used as input for risk evaluation and for decision-making steps regarding the treatment of these risks. This includes how the right way and strategy to treat existing risks.

The analysis technique used is the risk ranking method by determining the value of each risk through the risk priority value (RPN) obtained through the multiplication of the impact value (severity). frequency value (Occurrence). and detection value (Detection) [13].

RPN =Occurrence * Severity * Detection

This section may be divided by subheadings. It should provide a concise and pre-cise description of the experimental results. their interpretation. as well as the experi-mental conclusions that can be drawn.

Analysis of Failure in Post-Earthquake Disaster Distribution Logistics Process

The questionnaire had five Likert scales describing the condition's occurrence (Scale one (1) is the lowest. describes the risk event as very rare or never happens. and five (5) is the enormous scale. describes the risk event as Always happening or almost always happens); detection (Scale one (1) is the lowest. describes risk events are very difficult to detect. and five (5) is the enormous scale. describes the risk event is very easy to see). and severity (Scale one (1) is the lowest. represents minimal or no impact. and five (5) is the enormous scale. describes the effect is high). The Likert scale measures someone's opinion or several groups as to a phenomenon where the answer to each instrument item has a graduation from low to high.

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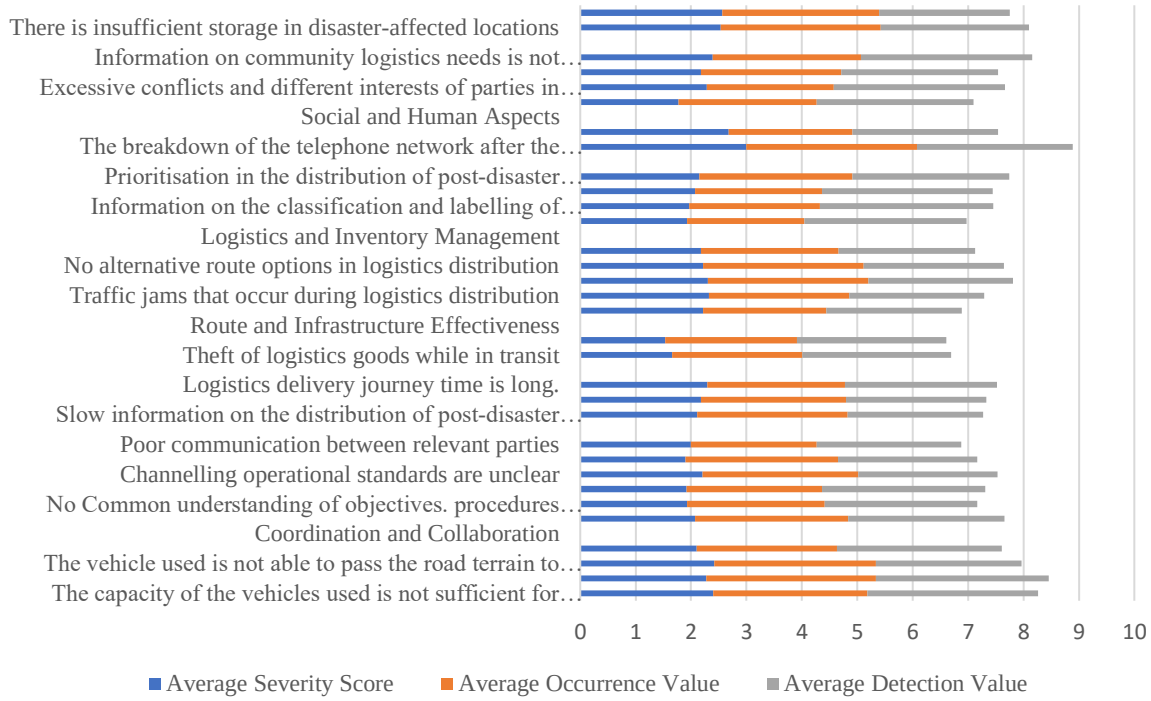

Figure 1. Calculation of Average Severity. Occurrence and Detection Value

Risk Priority Number

A risk priority number (RPN) is a numerical assessment of the risk assigned to a failure mode when conducting a Failure Modes and Effects Analysis (FMEA). It involves rating a failure mode's severity. probability of occurrence. and likelihood of detection on a numeric scale. usually ranging from 1 to 5. In this study. the RPN value of the risk event was sought for the five parameters studied. Table 1 shows the RPN value for each risk event.

Table 3. Risk Priority Number (RPN)

Parameter	Risk Event		Occurrence	Impact	Detection	RPN
Transport `Reliability and Capacity	a	The capacity of the vehicles used is not sufficient for the logistics distribution process	2.40	2.78	3.08	20.60
	b	The condition of the vehicle used is not good	2.27	3.07	3.12	21.66
	c	The vehicle used is not able to pass the road terrain to the affected location	2.42	2.92	2.62	18.44
	d	Operational support factors. fuel supply for logistics distribution vehicles is not sufficiently available	2.10	2.53	2.98	15.82
Coordination and	a	Unclear command during logistics distribution	2.07	2.77	2.82	16.14

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Parameter	Risk Event		Occurrence	Impact	Detection	RPN
Collaboration on	b	No Common understanding of objectives. procedures and responsibilities	1.93	2.48	2.76	13.23
	c	Lack of engagement and dedication in completing tasks and responsibilities.	1.92	2.44	2.95	13.80
	d	Channelling operational standards are unclear	2.21	2.81	2.51	15.55
	e	Ineffective information between parties involved in logistics distribution	1.90	2.75	2.52	13.14
	f	Poor communication between relevant parties	2.00	2.27	2.61	11.84
Response Time	a	Slow information on the distribution of post-disaster logistics.	2.11	2.72	2.44	14.00
	b	Complicated logistics distribution procedures lead to slow response times.	2.18	2.62	2.53	14.37
	c	Logistics delivery journey time is long.	2.29	2.49	2.74	15.66
Security	a	Theft of logistics goods while in transit	1.66	2.35	2.68	10.46
	b	Extortion of logistics transport drivers by local thugs	1.53	2.38	2.70	9.78
Route and Infrastructure Effectiveness	a	Roads used in logistics distribution have extreme geometrics	2.22	2.22	2.45	12.06
	b	Traffic jams that occur during logistics distribution	2.32	2.53	2.44	14.28
	c	Roads or bridges used in logistics distribution are damaged	2.30	2.90	2.61	17.40
	d	No alternative route options in logistics distribution	2.22	2.89	2.54	16.29
	e	Supporting infrastructure such as harbours and airports are damaged	2.18	2.48	2.47	13.37
Logistics and Inventory Management	a	Insufficient capacity of temporary storage areas for logistics items	1.93	2.12	2.92	11.94
	b	Information on the classification and	1.97	2.36	3.12	14.46

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Parameter	Risk Event		Occurrence	Impact	Detection	RPN
		labelling of logistics items is not clear.				
	d	Logistics inventory rotation is unclear. FIFO (First-In. First-Out) especially for perishable goods such as food	2.07	2.29	3.08	14.60
	e	Prioritisation in the distribution of post-disaster logistics is unclear	2.15	2.76	2.83	16.80
Communications and Technology Infrastructure	a	The breakdown of the telephone network after the earthquake made it difficult to coordinate the logistics team	3.00	3.08	2.81	25.98
	b	Logistics information system failure causes difficulty in prioritising shipments	2.68	2.23	2.63	15.13
Social and Human	a	Aspects Conflicts occurred along the logistics distribution route	1.77	2.50	2.83	11.63
	b	Excessive conflicts and different interests of parties in logistics distribution	2.28	2.30	3.09	13.60
	c	Poor coordination between related parties and the community	2.18	2.53	2.83	15.57
	d	Information on community logistics needs is not clearly identified	2.39	2.68	3.09	19.84
Emergency Infrastructure Preparedness	a	There is insufficient storage in disaster-affected locations	2.53	2.89	2.68	19.66
	b	Insufficient capacity of the storage post	2.56	2.83	2.36	17.07

Risk Analysis of Logistic Distribution Risk Event

Priority Number of Logistic Distribution Risk Event

Based on the results of research conducted through the distribution of questionnaires on risk management and control analysis. after calculating the RPN value of each. critical risks can be determined. The critical risk will be analysed further as the first step of the risk handling action. A risk is categorised as a critical risk if it selects an RPN value above the critical value. The critical value of RPN can be determined from the RPN values of all risks. Critical value (Total RPN)/(Number of Risks) = (502.79)/32 = 15.71

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Based on the critical value of RPN above. 14 critical risks are obtained. this is because the value of the three risks is above the critical value sought. The three risks that are above 15.71 can be seen in table 8 below.

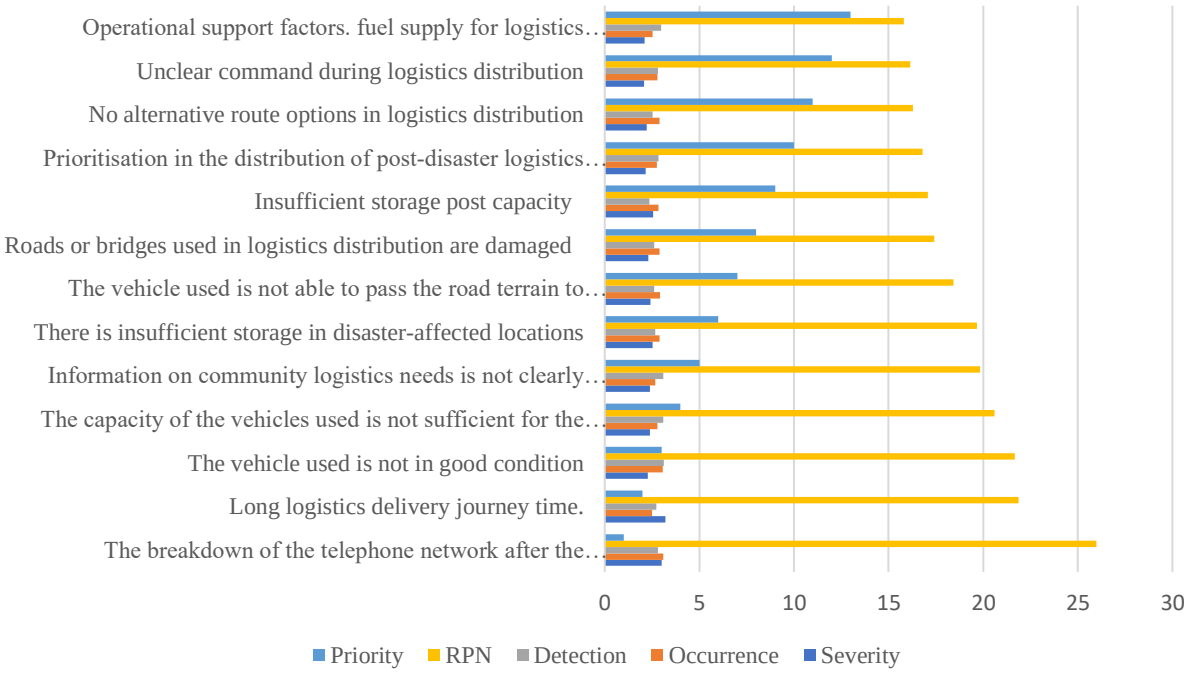

Figure 2. Risk Priority Number of Logistic Distribution Risk Event.

Logistics Distribution Risk Mitigation

After identifying and analyzing all existing risks. the next step is to propose control or risk mitigation measures to minimize the potential impact. This risk mitigation is aimed at risks with an RPN value above the critical value. In this study. there are 13 risks that require control or mitigation.

The control method was obtained based on the results of interviews conducted with experts from the BPBD of Padang City. the Transportation Department of Padang City. and the Social Department of Padang City. From these results. a summary of the handling or mitigation measures that can be taken for the 13 risks with an RPN above the critical value is presented in the following Table 6.

Table 6. Conditions During the Logistic Distribution Process. Critical Factors. and Needs

Code	Risk Event	Risk Mitigation
G1	The breakdown of the telephone network after the earthquake made it difficult to coordinate the logistics team	• Send basic logistical assistance such as food. after seeing the disaster site can record in the master book to immediately bring back the assistance that is deemed necessary.
C3	Long logistics delivery journey times	• Shorten the distribution/delivery route of goods • Perform maintenance on transport equipment

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Code	Risk Event	Risk Mitigation
A2	The vehicle used is not in good condition	• Conduct operational vehicle maintenance every 3 months • Have back up for operational vehicle rental
A1	The capacity of the vehicles used is not sufficient for the logistics distribution process	• The government or related parties immediately. send a mode of transport • Shorten the distribution/shipping route of goods
H4	Information on community logistics needs is not clearly identified	• Create a data processing master file so that it can estimate demand • Always check data needs in the field
I1	There is insufficient storage in disaster-affected locations	• Coordinate in advance with the field coordinator/recipient party
A3	The vehicle used is not able to pass the road terrain to the affected location	• Conduct route scenarios for distribution
I2	Insufficient storage post capacity	• Structuring well when arranged
F4	Prioritisation in the distribution of post-disaster logistics is unclear	• Coordinate in advance with the field coordinator/recipient party
B1	Unclear command during logistics distribution	• Perform reconciliation regularly • Conduct routine training so that no errors occur
A4	Operational support factors. fuel supply for logistics distribution vehicles is not sufficiently available	• Contacting manufacturers directly or working with more than one agent

CONCLUSION

Risk Events in the process of distributing post-disaster logistics assistance obtained 32 risk events which were identified by means of literature studies and then discussing them with related parties. Of the 32 risk events that have been identified and analyzed using the FMEA method. 13 risk events were obtained that had RPN values above the critical value, including the disconnection of the post-earthquake telephone network making it difficult to coordinate the logistics team, long travel time for logistics delivery, poor condition of the vehicles used, insufficient capacity of the vehicles used for the logistics distribution process, Information on the logistics needs of the community is not clearly identified, Inadequate storage space at the affected location, Vehicles used are not able to pass through the road terrain to the affected location, Roads or bridges used for logistics distribution are damaged, Capacity of the shelter post is insufficient, Priorities in post-disaster logistics distribution are unclear, There are no alternative route options in logistics distribution, Unclear command in logistics distribution, Operational support factors. insufficient fuel supply for logistics distribution vehicles.

As for the value of the level of risk importance. of the 32 risk events. only 1 event has a moderate level of risk probability classification. namely the risk of breaking the telephone

network after the earthquake makes it difficult to coordinate the logistics team.

Then after being identified and analysed. a mitigation action plan is carried out for each risk event that has an RPN value above the critical value to minimise the impact. For risk events that have a value above the critical point. risk mitigation is carried out that can be applied to minimise the impact.

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