Volume 4 Number 2 (2026)
July-December 2026
Page: 4218 – 4238

Journal of Creative Power and Ambition (JCPA)
https://edujavare.com/index.php/jcpa
E-ISSN: 3031-4054
DOI: 10.70610/jcpa.v4i02.1945

Building Disaster Logistics Resilience: Risk Analysis and Development Strategies for the Emergency Logistics Cluster in West Sumatra Province

Yovita Yulia M. Zai[1], Rahmi M. Nur[2], Edral Pratama[3]

[1,2] Undergraduate Program in Logistics - Faculty of Social and Business - Universitas Mercubaktijaya, Indonesia
[3] Regional Disaster Management Agency (BPBD) of West Sumatra Province, Indonesia
yovitayuliamzai@mercubaktijaya.ac.id[1*], rahmimnur@mercubaktijaya.ac.id[2], dracongpdg@yahoo.co.id[3]

Article history Submitted: 2026/08/14; Revised: 2026/10/11; Accepted: 2026/11/10

Abstract

Disaster logistics is a critical determinant of effective disaster management, as it ensures the timely, accurate, and coordinated availability, mobilization, and distribution of relief supplies. The complexity of disaster risks in West Sumatra Province, coupled with the substantial need for cross-sectoral coordination, necessitates the development of a more resilient logistics system through the establishment of a Disaster Logistics Cluster. This study aims to assess the risks associated with disaster logistics operations and determine priority strategies for developing the Emergency Logistics Cluster in West Sumatra Province. A quantitative approach with a descriptive-analytical design was employed, incorporating document analysis, observation, and expert panel assessments. Risk assessment was conducted using the Risk Matrix Score (RMS), while strategic priorities were determined using the Analytical Hierarchy Process (AHP). The findings indicate that disruptions to transportation access, weak inter-agency coordination, inaccurate needs assessment data, delays in relief distribution, and fragmented logistics information systems constitute the highest-priority risks. The AHP results identify strengthening the regulatory framework, organizational structure, and coordination mechanisms of the Logistics Cluster as the foremost strategic priority, followed by integrating logistics information systems, developing a network of emergency logistics hubs, enhancing human resource capacity, and strengthening multi-stakeholder partnerships. The study concludes that strengthening disaster logistics resilience requires an integrated approach combining risk management, institutional governance, information systems, logistics infrastructure, and cross-stakeholder collaboration to enhance the effectiveness of disaster response in West Sumatra Province.

Keywords Analytical Hierarchy Process; Disaster Logistics; Logistics Cluster; Logistics Resilience; Risk Matrix Score.

© 2026 by the authors. This is an open access publication under the terms and conditions of the Creative Commons Attribution 4.0 International (CC BY SA) license, https://creativecommons.org/licenses/by-sa/4.0/.

INTRODUCTION

Natural disasters pose one of the major challenges to sustainable development, as they not only cause loss of life but also disrupt logistics systems, supply chains, healthcare services, and the socioeconomic activities of affected communities. In any disaster event, the effectiveness of emergency response operations largely depends on the ability of the logistics system to procure, store, transport, and distribute relief supplies of the right type and quantity, to the right location and beneficiaries, at the right time, and in the appropriate condition. Consequently, disaster logistics has emerged as an important field within supply chain management, with a particular emphasis on multi-stakeholder coordination, resource management, and decision-making under conditions of uncertainty (Christopher & Peck, 2004; Kovács & Spens, 2007; Tomasini & Van Wassenhove, 2009).

Research developments over the past decade have increasingly positioned supply chain resilience as a key paradigm in the development of disaster logistics systems. Logistics resilience can be understood as the ability of a logistics system to anticipate, absorb, respond to, adapt to, and rapidly recover from disruptions while maintaining the effective distribution of relief supplies (Christopher & Peck, 2004; Otto & Dunens, 2021). Previous studies have shown that the effectiveness of humanitarian logistics operations is influenced by inter-agency coordination, information quality, infrastructure availability, human resource capacity, distribution network flexibility, and collaborative mechanisms among stakeholders (Fanjoy & Bragg, 2019; Hasanudin, Fitrinaingsih, Rosyida, & Noeruddin, 2021; Wibowo & Darsono, 2022). Accordingly, the development of resilient logistics systems is no longer concerned solely with cost efficiency but also with the capacity of the system to manage and withstand the various risks that arise throughout the disaster management cycle.

In Indonesia, disaster logistics management is particularly complex because of the country's archipelagic geography and high exposure to multiple disaster hazards. These conditions frequently create obstacles to relief distribution operations, including limited transportation access, infrastructure damage, inaccurate data on the needs of affected populations, distribution delays, insufficient warehousing capacity, and weak inter-agency coordination (Nugroho & Hidayah, 2020; Rizki & Wahdah, 2022; Nawawi et al., 2020). Furthermore, the increasing frequency of hydrometeorological disasters associated with climate change intensifies uncertainty in logistics operations, highlighting the need for systems capable of supporting rapid and adaptive decision-making (Gislason, Kennedy, & Witham, 2021; Adam, Walker, Bezerra, & Clayton, 2020).

As one of Indonesia's provinces with high disaster exposure, West Sumatra faces significant challenges in managing disaster logistics. The source material indicates that hydrometeorological disasters occurring toward the end of 2025 affected 16 regencies/cities, 59 subdistricts, and 198 *nagari* or urban villages, requiring logistics coordination across an extensive geographical area. Furthermore, differences in the duration of emergency response periods among affected regencies demonstrate that logistics requirements are dynamic and require an integrated cross-regional coordination mechanism. These conditions indicate that the complexity of disaster logistics is determined not only by the volume of relief supplies to be distributed but also by the capacity to manage information, prioritize needs, integrate resources, and establish effective collaboration among stakeholders.

The Indonesian government has responded to these challenges through the development of the Disaster Management Logistics Cluster, a multi-stakeholder coordination mechanism designed to enhance the effectiveness of logistics operations throughout disaster management. The Logistics Cluster forms part of the national coordination system and serves as a platform for planning, coordination, resource mobilization, information exchange, and the integration of logistics support into the Disaster Emergency Response Command System. This approach positions government agencies, private-sector organizations, humanitarian organizations, academic institutions, and communities as interconnected actors within a mutually supportive logistics network, thereby enabling resources to be utilized more effectively and accountably.

Despite these developments, previous studies have largely examined the effectiveness of relief distribution, humanitarian coordination, or logistics performance separately (Hanifah, Alawiyah, & Agustin, 2020; Hasanudin, Fitrinaingsih, Rosyida, & Noeruddin, 2021). Other studies have focused primarily on supply chain resilience in general without integrating operational risk identification with the prioritization of institutional development strategies through multi-criteria decision-making approaches (Otto & Dunens, 2021; Wibowo & Darsono, 2022). Moreover, the implementation of Logistics Clusters at the subnational level remains relatively recent, and studies addressing risk-based priorities for institutional development at the provincial level, particularly in West Sumatra, remain limited. This reveals a research gap, namely the absence of a systematic decision-making framework that integrates disaster logistics risk analysis with the prioritization of strategies for developing a regional Logistics Cluster.

To address this gap, this study integrates two complementary quantitative

approaches. The Risk Matrix Score (RMS) is employed to identify, assess, and map logistics risks based on the combination of the likelihood and impact of each identified risk. Subsequently, the Analytical Hierarchy Process (AHP) is applied to prioritize Logistics Cluster development strategies based on multi-criteria expert assessments.

Integrating these two methods is expected to generate strategic recommendations that consider not only the relative importance of each alternative but also the level of risk confronting the disaster logistics system. This approach is consistent with the development of risk-based decision-making in logistics and supply chain systems, in which risk assessment provides a foundation for designing strategies to strengthen system resilience (Village et al., 2020; Genon et al., 2022; Solina, Rahmawati, & Igiasi, 2022).

The novelty of this study lies in three main aspects. First, it integrates the Risk Matrix Score and Analytical Hierarchy Process within a unified analytical framework for developing a Disaster Management Logistics Cluster at the provincial level. Second, the study incorporates empirical information on disaster conditions and the logistics system of West Sumatra Province as the basis for developing a risk-based decision-making framework. Third, the proposed strategy prioritization extends beyond institutional considerations by incorporating information system integration, emergency logistics hub development, human resource capacity building, and stronger multi-stakeholder partnerships, thereby providing a more comprehensive approach than those adopted in previous studies.

Based on these considerations, this study aims to (1) identify and analyze the risks associated with disaster logistics operations in West Sumatra Province using the Risk Matrix Score; (2) determine priority strategies for developing the Emergency Logistics Cluster using the Analytical Hierarchy Process (AHP); and (3) formulate policy recommendations for building a more resilient, adaptive, and sustainable disaster logistics system. The findings indicate that strengthening institutional arrangements and coordination mechanisms constitutes the foremost priority for Logistics Cluster development, followed by the integration of logistics information systems, the development of a network of emergency logistics hubs, human resource capacity building, and the strengthening of multi-stakeholder partnerships. These findings are expected to contribute theoretically to the advancement of logistics and supply chain management research while providing practical insights for local governments and relevant stakeholders seeking to strengthen disaster logistics systems in West Sumatra Province.

METHODS

This study employed a quantitative approach using a descriptive-analytical research design. The quantitative approach was selected because the study aimed to assess the level of risk within the disaster logistics system while simultaneously determining priority strategies for developing the Emergency Logistics Cluster in West Sumatra Province through a multi-criteria decision-making approach. The research object was the disaster management logistics system in West Sumatra Province, with a particular focus on the development of the Logistics Cluster as initiated by the Indonesian National Disaster Management Agency (*Badan Nasional Penanggulangan Bencana* BNPB). The primary data source consisted of resource-person materials concerning the implementation of the Disaster Management Logistics Cluster, its legal and regulatory framework, coordination mechanisms, cluster benefits, and the case study of the 2025 hydrometeorological disasters in West Sumatra.

To obtain quantitative data, the study involved 15 experts representing the West Sumatra Provincial Disaster Management Agency (*Badan Penanggulangan Bencana Daerah* BPBD), the Health Office, the Indonesian National Armed Forces (TNI), the Indonesian National Police (Polri), the Indonesian Red Cross (PMI), academics specializing in logistics, and humanitarian organizations. The experts were selected using purposive sampling, with the primary eligibility criterion being a minimum of five years of professional experience in disaster logistics.

Data were collected through four stages: (1) a document review of the resource-person materials and relevant BNPB regulations; (2) observation of disaster logistics coordination mechanisms; (3) administration of a Risk Matrix questionnaire to the experts; and (4) administration of an AHP questionnaire using pairwise comparison matrices.

Data analysis was conducted in two stages. In the first stage, the Risk Matrix Score (RMS) was applied to identify and assess the level of risk associated with factors that could potentially hinder the development of the Emergency Logistics Cluster. Each identified risk was assessed according to its likelihood and impact, providing the basis for determining its relative risk level. In the second stage, the Analytical Hierarchy Process (AHP) was employed to determine the priority development strategies based on the relative weights assigned to each criterion and strategic alternative. The integration of RMS and AHP enabled the study to link the identification of critical disaster logistics risks with the systematic prioritization of

strategies for strengthening the Emergency Logistics Cluster in West Sumatra Province.

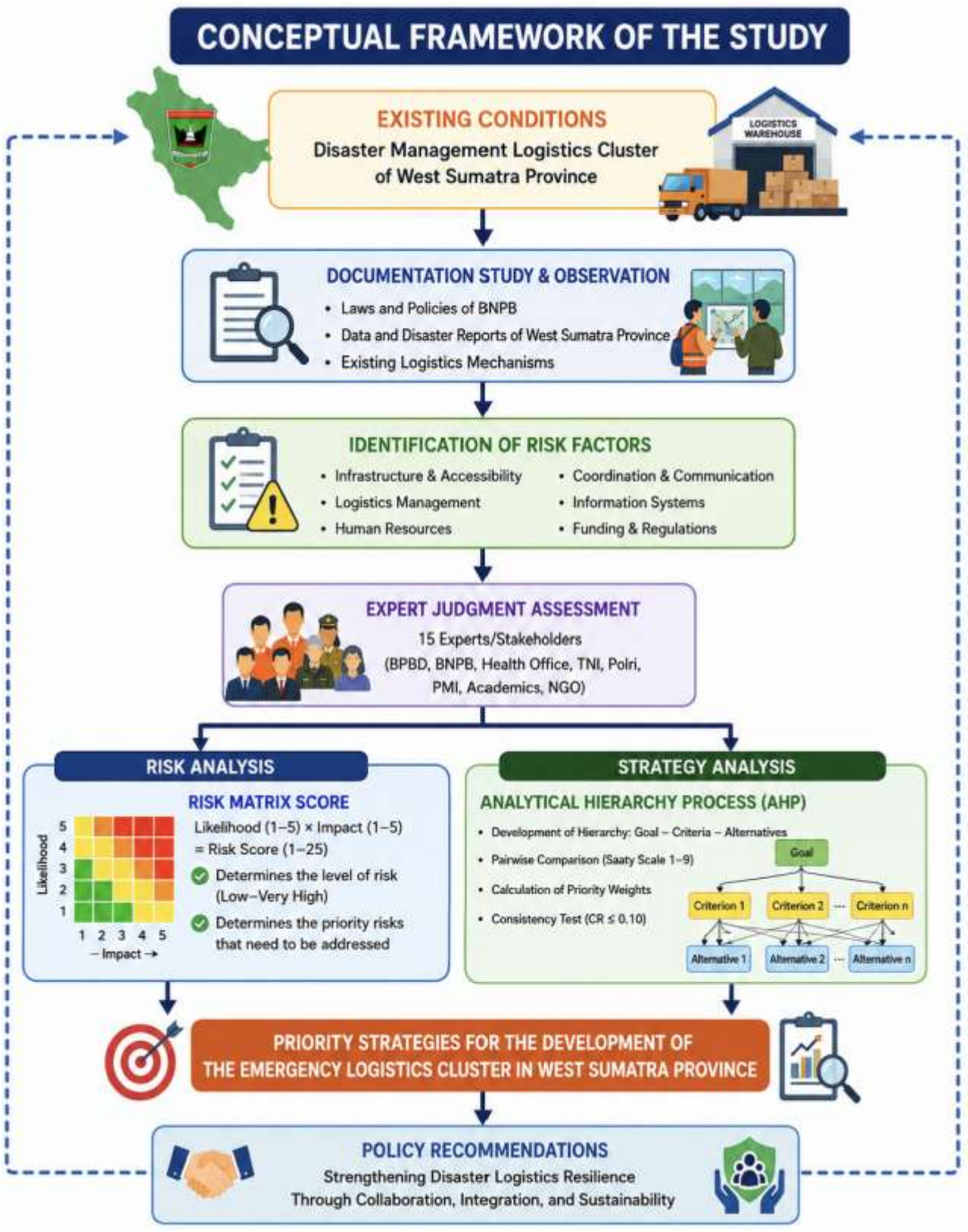


Figure 1. Conceptual Framework of the Study

Figure 1 illustrates that the study begins with an identification of the existing conditions of the Logistics Cluster in West Sumatra Province based on official documents and resource-person materials. Subsequently, risk factors are identified and analyzed using the Risk Matrix Score (RMS), while development strategies are evaluated using the Analytical Hierarchy Process (AHP). The integration of these two methods generates risk-based policy recommendations and strategic priorities aimed at strengthening disaster logistics resilience in West Sumatra Province.

FINDINGS AND DISCUSSION

Characteristics of the Expert Panel

The assessment of risks and the prioritization of development strategies for the Emergency Logistics Cluster in West Sumatra Province involved 15 experts selected using purposive sampling. The selection of experts was not intended to achieve statistical representation of the population, but rather to obtain informed judgments from individuals with relevant knowledge, operational experience, and decision-making authority in disaster logistics management. The expert panel comprised representatives from the West Sumatra Provincial Disaster Management Agency (BPBD), regency/municipal BPBDs, the Social Affairs Office, the Health Office, the National Search and Rescue Agency (Basarnas), the Indonesian National Armed Forces (TNI) or the Indonesian National Police (Polri), the Indonesian Red Cross (PMI) or humanitarian organizations, logistics service providers, regional data management or planning agencies, and academics.

The respondents were selected based on a minimum of three years of experience in disaster management, logistics, relief distribution, warehouse management, information systems, or emergency planning. Additional selection criteria included direct involvement in disaster response operations, an understanding of the geographical and disaster-related characteristics of West Sumatra Province, and the capacity to assess risk likelihood, impact, and appropriate risk mitigation strategies. All experts assessed the likelihood and impact of each identified risk using a five-point scale ranging from 1 to 5. The experts also conducted pairwise comparisons of the criteria and strategic alternatives using Saaty's 1–9 scale.

The involvement of experts from diverse stakeholder groups was essential because the Logistics Cluster operates as a multi-stakeholder coordination mechanism. The resource-person materials emphasize that the cluster is established to strengthen coordination, communication, collaboration, resource mobilization, and service integration within the Disaster Emergency Response Command System. The diversity of the expert panel also reflects the fundamental functions of the cluster in facilitating

the sharing of resources, knowledge, and information among stakeholders. Accordingly, the composition of the expert panel enabled the risk assessment and strategy prioritization processes to incorporate institutional, operational, humanitarian, logistical, informational, and academic perspectives relevant to strengthening disaster logistics resilience in West Sumatra Province.

Table 1. Composition of the Expert Panel

Code	Expert Affiliation/ Stakeholder Group	Number of Experts	Main Areas of Expertise Represented
P1–P3	West Sumatra Provincial Disaster Management Agency (BPBD)	3	Disaster management policy, emergency command, logistics and equipment management, and inter-regency/municipal coordination
P4–P5	Regency/Municipal Disaster Management Agencies (BPBDs)	2	Field operations, emergency post management, relief distribution, and access to disaster-affected areas
P6	Social Affairs Office	1	Basic-needs assistance management, warehousing, inventory management, and protection of displaced populations
P7	Health Office	1	Health logistics, health services for displaced populations, medicines, vulnerable-group needs, and health data management
P8	National Search and Rescue Agency (Basarnas)	1	Access to affected areas, initial mobilization, operational safety, and search-and-rescue support
P9	Indonesian National Armed Forces (TNI) or Indonesian National Police (Polri)	1	Personnel and vehicle mobilization, security, transportation support, and field operations
P10–P11	Indonesian Red Cross (PMI) or humanitarian organizations	2	Needs assessment, relief distribution, volunteer management, humanitarian services, and aid accountability
P12	Logistics service provider	1	Transportation, warehousing, distribution, fleet capacity, and logistics service networks

P13	Regional Development Planning Agency (Bappeda), Communication and Informatics Office (Diskominfo), or regional data management agency	1	Planning, data integration, information systems, and cross-sectoral program coordination
P14–P15	Academics specializing in logistics, supply chain management, or disaster management	2	Risk management, AHP, logistics network design, policy evaluation, and quantitative analysis
		Total	**15**

Codes P1 to P15 were used to maintain the confidentiality of the respondents' identities. The experts' personal names do not need to be disclosed in the final article, as their questionnaire responses constitute confidential individual-level data. Instead, the study reports the experts' institutional affiliations, areas of expertise, length of professional experience, and selection criteria. A list of the experts' names and their informed consent forms may be retained as supporting research documentation or internal supplementary materials and made available, where appropriate, upon request by the journal editors or reviewers.

Existing Conditions of Disaster Logistics in West Sumatra Province

The document review indicates that the development of the Disaster Management Logistics Cluster is supported by a strong policy and regulatory framework. The relevant legal foundations include Law No. 24 of 2007 on Disaster Management; BNPB Regulation No. 4 of 2018 on the Logistics and Equipment Management System; BNPB Regulation No. 6 of 2022 on the Logistics Cluster; Implementation Guideline No. 2 of 2023; and Decree of the Head of BNPB No. 308 of 2024 on Disaster Management Clusters.

The resource-person materials indicate that establishing the Logistics Cluster is necessary to provide a mechanism for coordination and strategic partnerships in logistics planning, implementation, monitoring, and evaluation. The establishment of the cluster is also driven by the need to engage multiple stakeholders before, during, and after disasters while strengthening the coordination, communication, integration, and accountability of logistics support.

Data on hydrometeorological disasters in West Sumatra demonstrate the considerable complexity of the geographical area covered by disaster logistics

operations. The disaster events of November 27–28, 2025, were preceded by rainfall reported to be equivalent to approximately two months of precipitation. The disasters affected 16 regencies/municipalities, 59 subdistricts, and 198 *nagari* or urban villages. A total of 12 regencies/municipalities declared an emergency response status. The extensive geographical coverage of the affected areas increased the complexity of needs assessment, route selection, fleet allocation, inventory control, and inter-agency coordination.

Risk Assessment Results

The risk assessment was conducted on 12 key risks identified through document review, resource-person materials, and validation by the expert panel. Each expert assessed the likelihood and impact of each identified risk using a five-point scale ranging from 1 to 5. The final value for each dimension was calculated using the arithmetic mean of the assessments provided by the 15 experts, while the overall risk score was obtained by multiplying the mean likelihood score by the mean impact score.

Mathematically, the Risk Matrix Score for each risk is formulated as follows:

$$R_i = \bar{L}_i \times \bar{I}_i$$

where $\bar{L}_i$ represents the mean **likelihood** score and $\bar{I}_i$ represents the mean **impact** score for risk (i), based on the assessments provided by the 15 experts.

The values presented in the following table represent the aggregated assessments of the 15 experts, structured according to the expert panel composition presented in **Table 1**. These values capture variations in risk perceptions across different stakeholder groups rather than relying on a single value predetermined by the researchers.

Table 2. Aggregated Risk Assessment Results from 15 Experts

Code	Logistics Risk	Mean Likelihood	Mean Impact	Risk Matrix Score	Risk Level	Rank
R1	Disrupted or limited transportation access to disaster-affected areas	4.60	4.87	22.39	Very High	1
R3	Weak inter-agency coordination and	4.27	4.60	19.63	Very High	2

	unclear allocation of roles and responsibilities					
R2	Inaccurate and delayed data on the needs of disaster-affected populations	4.27	4.47	19.06	Very High	3
R4	Delays in relief distribution to designated destinations	4.20	4.40	18.48	Very High	4
R5	Mismatch between the type and quantity of relief supplies and beneficiaries' needs	4.00	4.60	18.40	Very High	5
R6	Lack of integration among inter-organizational logistics information systems	3.93	4.60	18.09	Very High	6
R8	Lack of an operational mechanism for resource sharing	3.87	4.20	16.24	Very High	7
R7	Limited warehousing capacity, logistics hubs, and relief-handling facilities	3.67	4.33	15.89	High	8
R9	Limited availability of personnel trained in emergency logistics	3.47	4.07	14.10	High	9
R10	Unclear activation and command procedures for the regional Logistics Cluster	3.27	4.07	13.28	High	10

R11	Limited and delayed funding for logistics operations	3.33	3.93	13.11	High	11
R12	Low accountability and traceability of relief supplies	3.13	4.07	12.74	High	12

Source: Processed from the aggregated expert assessments, 2026.

The analysis indicates that seven risks fall within the **very high-risk** category, while five are classified as **high risk**. No risks were identified in the moderate- or low-risk categories. The highest-ranked risk was disrupted or limited transportation access to disaster-affected areas, with a Risk Matrix Score of 22.39. This score was derived from a mean likelihood of 4.60 and a mean impact of 4.87. The high assessment scores particularly reflect the perspectives of experts from regency/municipal Disaster Management Agencies (BPBDs), the National Search and Rescue Agency (Basarnas), the Indonesian National Armed Forces (TNI) or Indonesian National Police (Polri), logistics service providers, and humanitarian organizations, whose operational responsibilities involve the direct mobilization of relief supplies to disaster-affected areas.

Transportation access disruption ranked as the most critical risk due to the extensive geographical coverage of disaster events and the diverse geographical characteristics of West Sumatra. The disaster affected 16 regencies/municipalities, 59 subdistricts, and 198 *nagari* or urban villages, increasing the likelihood of simultaneous distribution disruptions across multiple areas. These conditions highlight the need for alternative route mapping, the designation of logistics hubs, systematic vehicle and fleet inventories, and the provision of alternative modes of transportation to maintain the continuity of relief distribution operations.

Weak inter-agency coordination and unclear allocation of roles and responsibilities ranked second, with a Risk Matrix Score of 19.63. This finding demonstrates that challenges in disaster logistics are not limited to physical and infrastructural constraints but also involve significant institutional and governance issues. The assessment is consistent with the resource-person materials, which emphasize the need for effective coordination mechanisms and strategic partnerships, the involvement of multiple stakeholders, and stronger communication and inter-agency synergy in disaster logistics operations.

Inaccurate and delayed data on the needs of disaster-affected populations ranked third, with a Risk Matrix Score of 19.06. This risk is associated with difficulties in

determining the appropriate quantity of relief supplies, distribution locations, beneficiary groups, and the urgency of required services. Needs data that are inaccurate, delayed, or not regularly updated may result in the accumulation of relief supplies in certain locations while other affected areas experience shortages. The resource-person materials also emphasize the importance of identifying vulnerable groups and maintaining disaggregated data to support the effective provision of healthcare services and basic necessities during disaster response operations.

Table 3. Distribution of Risk Categories

Risk Category	Score Range	Number of Risks	Percentage
Very High	16.00–25.00	7	58.33%
High	11.00–15.99	5	41.67%
Moderate	6.00–10.99	0	0.00%
Low	1.00–5.99	0	0.00%
Total		**12**	**100,00%**

Analytical Hierarchy Process Results

The Analytical Hierarchy Process (AHP) was employed to determine strategic priorities based on six criteria: K1, institutional arrangements and coordination; K2, infrastructure and facilities; K3, information and communication systems; K4, human resources; K5, funding and resources; and K6, multi-stakeholder partnerships. Each of the 15 experts performed pairwise comparisons using Saaty's 1–9 scale.

Since the assessments were provided by multiple experts, the values of each element in the pairwise comparison matrix were aggregated using the geometric mean, as formulated below:

$$\bar{a}_{ij} = \left(\prod_{k-1}^{n} a_{ij}^{(k)} \right)^{\frac{1}{n}}$$

where:

$\bar{a}_{ij}$ = the aggregated pairwise comparison value of element relative to element ;

$a_{ij}^{(k)}$ = the pairwise comparison value of element relative to element provided by expert ;

k = the expert index;

n = the total number of experts;

$\prod$ = the product operator representing the multiplication of all expert assessment values.

The use of the geometric mean preserves the reciprocal property of the AHP pairwise comparison matrix and reduces the influence of extreme judgments provided by any single respondent.

Table 4. Aggregated Pairwise Comparison Matrix of Criteria

Criteria	K1	K2	K3	K4	K5	K6
K1 Institutional Arrangements and Coordination	1,000	1,294	1,873	2,745	3,480	4,911
K2 Infrastructure and Facilities	0,773	1,000	1,000	2,071	2,874	3,137
K3 Information and Communication Systems	0,534	1,000	1,000	1,755	1,888	2,511
K4 Human Resources	0,364	0,483	0,570	1,000	1,356	1,873
K5 Funding and Resources	0,287	0,348	0,530	0,738	1,000	1,180
K6 Multi-Stakeholder Partnerships	0,204	0,319	0,398	0,534	0,847	1,000

The eigenvector calculation results indicate that **institutional arrangements and coordination** received the highest priority weight of 0.3178. Infrastructure and facilities ranked second with a weight of 0.2259, while information and communication systems ranked third with a weight of 0.1860.

Table 5. Criteria Weights and Rankings for Logistics Cluster Development

Code	Kriteria	Weight	Percentage	Rank
K1	K1 Institutional Arrangements and Coordination	0,3178	31,78%	1
K2	K2 Infrastructure and Facilities	0,2259	22,59%	2
K3	K3 Information and Communication Systems	0,1860	18,60%	3
K4	K4 Human Resources	0,1150	11,50%	4
K5	K5 Funding and Resources	0,0865	8,65%	5
K6	K6 Multi-Stakeholder Partnerships	0,0688	6,88%	6
	Total	**1,0000**	**100,00%**	

The weight assigned to institutional arrangements and coordination, accounting for 31.78%, indicates that the experts considered the establishment of a formal organizational structure, clear allocation of roles and responsibilities, activation procedures, and command mechanisms to be essential prerequisites for Logistics Cluster development. Infrastructure and facilities received a weight of 22.59%, reflecting the critical role of warehousing capacity, distribution hubs, transportation

fleets, and transport accessibility in ensuring the continuity of logistics services. Information and communication systems accounted for 18.60%, highlighting the importance of accurate and timely information on needs, inventory levels, locations, and shipment status for effective logistics and distribution decision-making.

The consistency test yielded a maximum eigenvalue ((\lambda_{\max})) of 6.0201, a Consistency Index (CI) of 0.0040, and a Consistency Ratio (CR) of 0.0032. Since the CR value is below the acceptable threshold of 0.10, the aggregated pairwise comparison matrix was considered consistent, indicating an acceptable level of logical consistency in the expert judgments.

Table 6. Consistency Test Results for the Criteria Matrix

Component	Value
Number of criteria ()	6
Maximum eigenvalue (λ_{max})	6,0201
Consistency Index	0,0040
Random Index	1,2400
Consistency Ratio	0,0032
Acceptance threshold	≤ 0,1000
Decision	Consistent

The five strategic alternatives compared in the AHP analysis were: A1, strengthening regulations, organizational structures, and coordination mechanisms; A2, developing logistics centers and hubs; A3, integrating logistics information systems and data; A4, enhancing human resource competencies and preparedness; and **A5**, strengthening partnerships and resource-sharing mechanisms.

Table 7. Local Weights of Strategic Alternatives for Each Criterion

Strategic Alternative	K1	K2	K3	K4	K5	K6
A1 Strengthening regulations, organizational structures, and coordination mechanisms	0,43	0,12	0,11	0,14	0,13	0,17
A2 Developing logistics centers and hubs	0,12	0,44	0,15	0,14	0,21	0,13
A3 Integrating logistics information systems and data	0,18	0,15	0,45	0,17	0,15	0,13
A4 Enhancing human resource competencies and preparedness	0,15	0,14	0,18	0,41	0,15	0,16
A5 Strengthening partnerships and resource-sharing mechanisms	0,12	0,15	0,11	0,14	0,36	0,41
Total	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**

The global weights were obtained by multiplying the local weight of each strategic alternative under each criterion by the corresponding criterion weight. The synthesis results indicate that strengthening regulations, organizational structures, and coordination mechanisms emerged as the highest-priority strategy. Integration of logistics information systems and data ranked second, while the development of logistics centers and hubs ranked third.

Table 8. Global Priorities of Logistics Cluster Development Strategies

Rank	Code	Strategy	Global Weight	Percentage
1	A1	Strengthening regulations, organizational structures, and cluster coordination mechanisms	0,2190	21,90%
2	A3	Integrating disaster logistics information systems and data	0,2155	21,55%
3	A2	Developing emergency logistics centers and hub networks	0,2007	20,07%
4	A4	Enhancing human resource competencies and preparedness	0,1888	18,88%
5	A5	Strengthening partnerships and resource-sharing mechanisms	0,1760	17,60%
		Total	**1,0000**	**100,00%**

The difference between the weights of strategies A1 and A3 is only 0.35 percentage points, indicating that institutional strengthening and information integration are perceived as nearly equally important. A robust cluster structure cannot operate effectively without integrated data on needs, inventory levels, shipments, and the capacities of cluster members. Conversely, an information system cannot be optimally utilized unless responsibilities for data collection, validation, updating, and utilization are clearly defined within the institutional structure.

Integration of Risk Matrix Score and AHP Results

The integration of the Risk Matrix Score (RMS) and Analytical Hierarchy Process (AHP) results demonstrates a consistent relationship between priority risks and their corresponding mitigation strategies. The risk of transportation access disruption supports the development of emergency logistics hubs and alternative transportation options. Coordination-related risks reinforce the need to strengthen regulations and the institutional structure of the Logistics Cluster. Meanwhile, risks associated with inaccurate needs data and the lack of integration among logistics information systems

highlight the importance of developing a shared and integrated logistics information system.

Table 9. Integration of Critical Risks and Priority Strategies

Critical Risk	Score	Primary Strategy	Recommended Program
Transportation access disruption	22,39	A2	Alternative route mapping, logistics hub development, multimodal transportation arrangements, and standby transportation contracts
Weak inter-agency coordination	19,63	A1	Establishment of the cluster organizational structure, activation SOPs, clear allocation of roles and responsibilities, and a coordination center
Inaccurate needs assessment data	19,06	A3	Integrated data system for needs, inventory levels, beneficiaries, and distribution status
Delays in relief distribution	18,48	A2 and A3	Pre-positioning of relief supplies, route optimization, and shipment tracking
Mismatch between relief supplies and actual needs	18,40	A3 and A4	Standardization of needs assessment, classification of relief supplies, and personnel training
Lack of integration among logistics information systems	18,09	A3	Data standards, system interoperability, integrated dashboards, and information-sharing protocols
Lack of an operational resource-sharing mechanism	16,24	A1 and A5	Inventory of cluster members' capacities and procedures for resource mobilization
Limited warehousing capacity and facilities	15,89	A2	Development of primary warehouses, buffer warehouses, and logistics consolidation points
Limited availability of trained personnel	14,10	A4	Training, simulation exercises, certification, and establishment of a roster of personnel ready for deployment

The results indicate that the development of the Emergency Logistics Cluster in West Sumatra Province should begin with the establishment of a clear institutional framework, while being implemented in parallel with the integration of logistics information systems and the development of an emergency logistics hub network. These strategies should subsequently be supported by strengthening human resource competencies and enhancing multi-stakeholder partnerships.

CONCLUSION

This study aimed to analyze the risks associated with disaster logistics operations and determine priority strategies for developing the Emergency Logistics Cluster in West Sumatra Province as an effort to strengthen disaster logistics resilience. Based on the assessment of existing conditions, the Risk Matrix Score (RMS) analysis, and the Analytical Hierarchy Process (AHP) modeling, the findings demonstrate that the major challenges facing disaster logistics in West Sumatra Province arise not only from the high exposure to hydrometeorological hazards and the geographical characteristics of the region but also from institutional arrangements, cross-sectoral coordination, the quality of needs assessment data, limitations in logistics infrastructure, and the insufficient integration of information systems among stakeholders. These conditions indicate that strengthening logistics resilience cannot be achieved solely through additional infrastructure and facilities; rather, it requires stronger governance, collaboration, and integrated coordination mechanisms.

The risk analysis identified transportation access disruptions to disaster-affected areas, weak inter-agency coordination, inaccurate data on the needs of affected populations, delays in relief distribution, and fragmented logistics information systems as the highest-priority risks. These risks are interrelated and therefore require a systemic rather than fragmented approach to risk mitigation. These findings reinforce the views expressed in the resource-person materials that the establishment of a Logistics Cluster is intended to strengthen coordination, communication, collaboration, resource mobilization, and mechanisms for sharing information and resources among institutions throughout the disaster management cycle.

The AHP results indicate that strengthening the regulatory framework, organizational structure, and coordination mechanisms of the Logistics Cluster constitutes the highest-priority strategy, followed by the integration of logistics information systems, the development of a network of emergency logistics centers and hubs, human resource capacity building, and the strengthening of partnerships and resource-sharing mechanisms. This prioritization suggests that the development of logistics resilience depends more strongly on institutional preparedness and effective

governance than on infrastructure development alone. Accordingly, the Emergency Logistics Cluster in West Sumatra Province should be developed progressively through institutional strengthening, standardization of operational procedures, integration of data and information, enhancement of human resource capacity, and the development of logistics networks involving government agencies, the private sector, humanitarian organizations, academic institutions, and communities.

From a theoretical perspective, this study contributes to the development of disaster logistics management research by integrating the Risk Matrix Score and Analytical Hierarchy Process (AHP) within a unified risk-based decision-making framework. The integration of these methods enables researchers not only to identify and assess risk levels but also to prioritize development strategies according to the relative importance of the evaluation criteria. This approach may be replicated in disaster logistics studies in other provinces and extended to healthcare logistics, humanitarian logistics, and critical supply chain systems.

From a practical perspective, the findings can serve as a reference for the Government of West Sumatra Province, the Regional Disaster Management Agency (BPBD), and Logistics Cluster members in formulating policies for the establishment and strengthening of the Disaster Management Logistics Cluster. The resulting strategic priorities can provide a basis for developing a cluster development roadmap, establishing standard operating procedures, developing integrated logistics information systems, establishing networks of warehouses and emergency logistics hubs, and strengthening human resource capacity and multi-stakeholder partnerships to improve the effectiveness of disaster response operations.

This study has several limitations. The quantitative analysis was conducted using an expert judgment model developed on the basis of existing conditions and information obtained from the resource persons. Future studies should involve a broader expert panel and incorporate additional variables not examined in the present study, including logistics costs, distribution lead times, transportation network optimization, and warehouse capacity simulations, all of which may influence the effectiveness of disaster logistics systems.

Future research is recommended to develop a more comprehensive decision-making model involving expert panels from multiple provinces and integrating AHP with methods such as the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Failure Mode and Effects Analysis (FMEA), or Bayesian Networks, thereby enabling interdependencies among risks to be modeled more dynamically. Future studies

should also explore the development of a digital Disaster Logistics Decision Support System (DL-DSS) integrating Geographic Information Systems (GIS), the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data Analytics to support real-time decision-making in disaster logistics operations. In addition, further research on the design of emergency logistics center and hub networks, warehouse location optimization, Logistics Cluster performance evaluation using Key Performance Indicators (KPIs), and the implementation of digital humanitarian logistics in West Sumatra Province represents an important research agenda for advancing an adaptive, resilient, and sustainable disaster logistics system.

REFERENCES

Adam, A., Walker, T. R., Bezerra, J. C., & Clayton, A. (2020). Policies to reduce single-use plastic marine pollution in West Africa. *Marine Policy*, *116*, 103928.

Agdal, R., Midtgård, T., & Meidell, V. (2019). Can asset-based community development with children and youth enhance the level of participation in health promotion projects? A qualitative meta-synthesis. *International Journal of Environmental Research and Public Health, 16*(19), 3778.

Badan Nasional Penanggulangan Bencana. (2018). *Peraturan Badan Nasional Penanggulangan Bencana Nomor 4 Tahun 2018 tentang Sistem Manajemen Logistik dan Peralatan*. BNPB.

Badan Nasional Penanggulangan Bencana. (2022). *Peraturan Badan Nasional Penanggulangan Bencana Nomor 6 Tahun 2022 tentang Klaster Logistik Penanggulangan Bencana*. BNPB.

Badan Nasional Penanggulangan Bencana. (2023). *Petunjuk Pelaksanaan Nomor 2 Tahun 2023 tentang Pembentukan Klaster Logistik Penanggulangan Bencana Daerah*. BNPB.

Badan Nasional Penanggulangan Bencana. (2024). *Keputusan Kepala Badan Nasional Penanggulangan Bencana Nomor 308 Tahun 2024 tentang Klaster Penanggulangan Bencana*. BNPB.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management, 15*(2), 1–14.

Fanjoy, V., & Bragg, B. (2019). Disaster logistics and humanitarian response: A review of current practices. *Journal of Humanitarian Logistics and Supply Chain Management, 9*(3), 312–329.

Genon, S., et al. (2022). Decision-making under uncertainty: Integrating risk assessment into strategic planning. *Sustainability, 14*(5), 2678.

Gislason, M., Kennedy, A., & Witham, S. (2021). Community resilience and disaster preparedness: Lessons for public health systems. *International Journal of Environmental Research and Public Health, 18*(11), 5905.

Hanifah, R., Alawiyah, T., & Agustin, R. (2020). Disaster logistics performance measurement using supply chain perspectives. *Journal of Disaster Research, 15*(4), 510–520.

Hasanudin, Fitrinaingsih, Rosyida, & Noeruddin. (2021). Humanitarian logistics collaboration in disaster management. *Journal of Humanitarian Logistics and Supply Chain Management, 11*(2), 245–264.

International Organization for Standardization. (2018). *ISO 31000:2018 Risk management—Guidelines*. ISO.

Kovács, G., & Spens, K. M. (2007). Humanitarian logistics in disaster relief operations. *International Journal of Physical Distribution & Logistics Management, 37*(2), 99–114.

Marchlewska, M., Cichocka, A., Łozowski, F., Górska, P., & Winiewski, M. (2019). In search of an imaginary enemy: Catholic collective narcissism and the endorsement of gender conspiracy beliefs. *Journal of Social Psychology, 159*(6), 766–779.

Nawawi, et al. (2020). Disaster preparedness and logistics coordination in Indonesia. *International Journal of Disaster Risk Reduction, 46*, 101498.

Nugroho, A., & Hidayah, N. (2020). Supply chain resilience in disaster response: Evidence from Indonesia. *Journal of Asian Business and Economic Studies, 27*(3), 287–304.

Otto, A., & Dunens, E. (2021). Disaster supply chain resilience: A systematic literature review. *International Journal of Disaster Risk Reduction, 58*, 102206.

Rizki, M., & Wahdah, N. (2022). Logistics coordination for disaster response in Indonesia: Challenges and opportunities. *Journal of Disaster Studies, 8*(2), 89–101.

Saaty, T. L. (1980). *The Analytic Hierarchy Process*. McGraw-Hill.

Saaty, T. L. (2008). Decision making with the Analytic Hierarchy Process. *International Journal of Services Sciences, 1*(1), 83–98.

Shen, Z. J. M., & Daskin, M. S. (2005). Trade-offs between customer service and cost in integrated supply chain design. *Manufacturing & Service Operations Management, 7*(3), 188–207.

Sheffi, Y. (2005). *The resilient enterprise: Overcoming vulnerability for competitive advantage*. MIT Press.

Solina, Rahmawati, & Igiasi. (2022). Multi-criteria decision analysis for humanitarian logistics planning. *Journal of Humanitarian Logistics and Supply Chain Management, 12*(4), 451–470.

Tomasini, R., & Van Wassenhove, L. N. (2009). *Humanitarian logistics*. Palgrave Macmillan.

Village, J., et al. (2020). Risk management approaches in emergency logistics systems. *Safety Science, 129*, 104817.

Wibowo, A., & Darsono. (2022). Developing disaster logistics resilience using multi-criteria decision making. *International Journal of Disaster Risk Reduction, 74*, 102911.

World Health Organization. (2021). *Health emergency and disaster risk management framework*. World Health Organization.