IDENTIFICATION OF RELEVANT SELECTION CRITERIA FOR HYDROMETEOROLOGICAL DISASTER LOGISTICS HUB LOCATIONS IN WEST JAVA BASED ON MULTI-ACTOR PREFERENCES

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ABSTRACT
This research addresses the need for relevant selection criteria to determine hydrometeorological disaster logistics hub locations in West Java Province, where disaster frequency is high and logistics distribution planning remains largely reactive and unsystematic. The study aims to identify and validate location selection criteria based on multi-actor preferences within a pre-disaster mitigation framework. Evaluation criteria were identified through a literature review, policy analysis, and stakeholder consultation, followed by criteria weighting based on multi-actor preferences. The study assumes reliable data availability, relative stability of stakeholder preferences, rational decision-making, and feasible logistics infrastructure development. The analysis identified six main criteria and 21 sub-criteria. Policy support received the highest weight (0.21), followed by accessibility (0.20) and affected population (0.18), while disaster vulnerability received the lowest weight (0.10). The pairwise comparison matrix demonstrated acceptable consistency (CR = 0.04). The novelty of this research lies in developing a pre-disaster, multi-actor preference-based framework for identifying logistics hub selection criteria that integrates spatial dynamics, hydrometeorological risks, and institutional and social perspectives. The findings provide a structured basis for determining disaster logistics hub locations and offer both conceptual and practical contributions to more inclusive, adaptive, systematic, and sustainable disaster logistics planning in disaster-prone regions such as West Java Province.

Keywords: disaster logistics; logistics hub points; hydrometeorology; AHP.

INTRODUCTION

The growing frequency, scale, and complexity of disasters have fundamentally reshaped traditional Supply Chain Management (SCM), giving rise to the field of Humanitarian Supply Chain Management (HSCM). Unlike commercial supply chains that mainly focus on reducing costs and increasing profits, humanitarian supply chain management (HSCM) emphasizes speed, flexibility, fairness, and coordination in highly uncertain situations. Activities such as procurement, storage, transportation, and distribution of relief goods can account for up to 80% of disaster response work. This shows that logistics plays a crucial role in saving lives and reducing human suffering (Negi, 2021). Since the 2004 Indian Ocean tsunami, researchers and humanitarian organizations have given greater attention to building stronger, more adaptive supply chains, especially to handle large and recurring disasters such as earthquakes, pandemics, and climate-related hazards (Karuppiah et al., 2025).

Among many disaster types, hydrometeorological hazards are among the most frequent and most challenging for humanitarian logistics. Disasters like floods, landslides, droughts, heavy rain, and coastal flooding occur frequently, affect wide areas, and vary in intensity. This makes planning and preparedness more difficult and puts heavy pressure on logistics infrastructure. In Indonesia, hydrometeorological disasters make up most disaster events in recent years (BNPB, 2022; 2023). Global frameworks from UNDRR and IPCC reports also say that these risks are increasing. They stress the urgent need for better preparedness strategies using early warning systems, spatial information, and flexible planning methods (IPCC, 2022; UNDRR & ISC, 2020).

The success of humanitarian response depends heavily on how well humanitarian supply chain management (HSCM) operates, especially when roads, bridges, and communication systems are damaged or difficult to use. Transportation and communication problems often delay aid delivery. This leads to unmet needs and inefficient use of limited resources (Quispe et al., 2025). Under such conditions, the strategic location of logistics hubs becomes particularly important. Well-located logistics hubs can reduce response time, reach more affected people, lower operational costs, and make aid distribution fairer and more effective (Kovács & Sigala, 2021; Naganawa et al., 2024). Therefore, choosing locations for logistics facilities becomes a key issue in humanitarian logistics and disaster management research.

To deal with the complexity of choosing facility locations, many studies use Multi-Criteria Decision Making (MCDM) methods. These methods help decision-makers compare location options using multiple criteria simultaneously, such as accessibility, risk level, capacity, and distance to affected people. Recent research shows that combined methods like AHP–TOPSIS, optimization models, and coverage-based location models make facility location analysis more detailed and systematic (Mohammadnazari et al., 2022). Lately, artificial intelligence and machine learning tools such as neural networks, support vector machines, and logistic regression have also been used to improve risk prediction and support data-driven decision-making in humanitarian cases (Akbarian et al., 2022; AbdelAziz et al., 2024).

Even with these improvements, most humanitarian facility location models remain highly technical. Many studies only focus on numbers, efficiency, and technical limits. Issues such as governance, coordination between institutions, and differences among stakeholders are only briefly discussed. In real situations, humanitarian logistics involves many actors, including government agencies, humanitarian organizations, private logistics companies, and local communities. Each actor has different goals, knowledge, and views about risk, and these differences affect how decisions are made. However, most existing models do not clearly show how to combine these different actor preferences when deciding the criteria and their importance (Praneetpholkrang & Huynh, 2020; Jiang et al., 2021; Zabihi et al., 2023).

This problem is clearly evident in disaster-prone areas such as West Java Province, Indonesia. In 2023, West Java recorded the highest number of disaster events in the country, with more than 98% caused by hydrometeorological hazards (BNPB, 2024). Data shows that the first logistics response in affected areas usually occurs between 20 and 32 hours after the disaster begins. These delays show ongoing problems in preparedness, coordination, and planning of facility locations, especially in areas with poor access and weak infrastructure. At present, decisions about the location of a logistics hub in West Java are mostly made after a disaster occurs. These decisions are mainly based on short-term access and distance, without systematic spatial analysis or evaluation of logistics capacity before a disaster occurs.

In addition, even though policy frameworks like the West Java Disaster Logistics Cluster encourage cooperation among many actors, in practice, the system is still controlled primarily by a single institution. The lack of involvement from humanitarian organizations, transport companies, and local communities limits the use of local knowledge, reduces the ability to draw on resources from different groups, and makes it harder to adapt quickly to changing field conditions. A similar situation can also be found in humanitarian logistics research, where many facility location models pay little attention to governance issues and to how interactions among different actors affect effective response strategies (Guo & Matsuda, 2023; Rodríguez-Espíndola et al., 2018).

Another major challenge in humanitarian logistics planning is uncertainty about space and time, especially before disasters occur. Decision makers do not know exactly when, where, and how big the next disaster will be, which makes it hard to decide how to allocate resources and where to place facilities (Wei et al., 2024; Ge et al., 2022). Research shows that response plans that focus solely on post-disaster actions are usually reactive and inefficient because they lack early preparation (Cui et al., 2021; Cao, 2023). On the other hand, planning before disasters using past data, risk maps, and different scenario analyses can help create logistics systems that are stronger and more flexible in the face of uncertainty (Khajehei & Chandrasekhar, 2024; Ludovico et al., 2023). This also aligns with international recommendations that emphasize the importance of risk-based preparedness and proactive logistics planning (UNDRR & ISC, 2020; IPCC, 2022).

Based on this situation, there is still a clear gap in research on how to select suitable locations for humanitarian logistics hubs that account for the preferences of multiple actors during the pre-disaster stage. Most existing studies focus on technical and spatial factors. At the same time, social and governance aspects from the perspectives of stakeholders such as government agencies, humanitarian organizations, and local communities are often insufficiently addressed. This weakness can reduce transparency, trust, and the real usefulness of location decisions in disaster preparedness.

This research seeks to fill this gap by offering a framework grounded in the preferences of multiple actors to help identify and organize the criteria for selecting logistics hub locations for hydrometeorological disasters in West Java Province, Indonesia. By combining technical, spatial, and social aspects using a multi-actor decision-

making approach, the framework aims to improve cooperation, make planning more reliable, and help the system adapt better in pre-disaster logistics planning. This research also contributes to humanitarian logistics research by introducing a model that addresses governance issues and provides practical guidance to support risk-based preparedness and more resilient humanitarian supply chain systems in disaster-prone areas such as West Java.

LITERATURE REVIEW

1. Humanitarian Supply Chain Management Concept

Humanitarian Supply Chain Management (HSCM) is becoming more important because the number of natural and man-made disasters continues to increase (Kovács & Sigala, 2021). The main purpose of HSCM is to save lives, reduce human suffering, and support community recovery after disasters. Unlike commercial supply chains that focus on profit, HSCM places greater emphasis on urgency, the fairness of aid distribution, and humanitarian values (Anjomshoae et al., 2023). HSCM can be described as a network that manages the flow of goods, services, money, and information between donors, suppliers, humanitarian organizations, and affected people, with the primary purpose of providing physical assistance to those in need (Chowdhury et al., 2024). Depending on the type of disaster, humanitarian supply chains are usually associated with sudden disasters, whereas slower disasters are more often referred to as humanitarian relief chains (Ahmad et al., 2024).

2. Disaster Relief Operations (DRO)

A disaster relief operations (DRO) logistics system is a set of activities that includes planning what is needed, buying supplies, storing them, transporting and distributing them, receiving goods at the destination, handling unused items, and reporting how everything is managed (Chari & Novukela, 2023). These activities aim to ensure that aid is delivered quickly, accurately, and in line with what disaster-affected people really need (Kamyabniya et al., 2024). While sharing many similarities with commercial SCM in terms of processes, DRO presents significantly more complex challenges because it must operate in situations full of uncertainty, is urgent, and takes place within unstable infrastructure (Insani et al., 2024).

DROs have fundamentally different characteristics from commercial logistics systems. DROs operate in emergencies, often without warning, with damaged infrastructure, urgent needs, and complex cross-organizational coordination. The Disaster Relief Logistics (DRO) provides a systematic framework for understanding the flow of disaster relief logistics, from needs planning and procurement to storage and distribution, to accountability, all of which rely heavily on strategic and adaptive logistics hub locations to address spatial disaster risks (Delshad et al., 2024). In disaster management, selecting logistics hub locations is a key determinant in accelerating response times, ensuring accurate aid distribution, and minimizing unmet requests. The application of DRO principles and characteristics allows for the development of a logistics hub location selection model that is spatially and temporally efficient and responsive to the operational complexities of disaster management in disaster-prone areas (F. Wang et al., 2023).

3. Disaster Concept

From a modern view, the meaning of disaster has become broader and more specific. The World Health Organization (WHO, 2007) defines a disaster as an event that causes damage, environmental disruption, loss of life, or decline in health services, and requires assistance from outside the affected community. This means that a disaster is not only a natural event but also a condition in which local capacity is insufficient to manage its impact. In Indonesia, the National Disaster Management Agency (BNPB) and Law No. 24 of 2007 (Republic of Indonesia, 2007) define a disaster as an event or series of events that threaten and disturb people's lives. Disasters can be caused by natural, non-natural, or human factors and can result in human casualties, environmental damage, material loss, and psychological impacts. This definition shows that disasters are not only physical events but also affect social and economic conditions. Studies on disaster types continue to develop as extreme events become more frequent and more complex worldwide. In Indonesia, disaster classification is clearly regulated by Law No. 24 of 2007, which serves as the main reference for disaster management. This law divides disasters into three main categories: natural, non-natural, and social.

4. Theoretical Basis of the Selection Criteria

Theoretical studies are used to identify the scientific basis for the criteria needed to determine the location of disaster logistics hubs. The following five groups of concepts serve as the foundation for developing the six criteria and 21 sub-criteria applied in this research.

Disaster risks and hazards. The risk concept developed by Birkmann (2007) and Louzeiro et al. (2023) defines risk as a function of hazard, exposure, vulnerability, and capacity. This perspective requires location suitability

to be assessed through the frequency of disaster events, the level of regional risk, and the condition of critical infrastructure, which together form the Disaster Vulnerability (KB) criterion.

Infrastructure and transportation networks. Koks et al. (2019) and Gerges et al. (2022) show that road networks, bridges, telecommunications, electricity, and supporting facilities significantly influence distribution speed and operational coordination. Because this concept covers two distinct dimensions, it yields two criteria: Accessibility (AK), which concerns proximity to main roads, distribution centers, and alternative transport modes; and Infrastructure (IN), which concerns the availability of road networks, supporting facilities, communications, electricity, and water.

Population vulnerability and exposure. Cutter et al. (2003) and Flanagan et al. (2011) emphasize that population density and socio-economic vulnerability determine a community's level of exposure to disasters. Because a logistics hub must reach affected populations effectively, proximity to densely populated areas, the potential number of beneficiaries, and the level of social vulnerability are integrated into the Affected Population (PT) criterion.

Policy and spatial planning considerations. King et al. (2016) emphasize that the location of public facilities must comply with spatial planning regulations so that development and operation can proceed without legal obstacles. This consideration gives rise to the Policy Support (DK) criterion, which ensures that a hub location is not situated within a restricted zone and can be used legally and sustainably.

Efficiency of logistics distribution and operational facilities. Balcik and Beamon (2008) and Sheu (2010) emphasize that the effectiveness of humanitarian aid depends heavily on distance, travel time, warehouse capacity, logistics resources, and ease of mobilization. Regional operational capacity and readiness are therefore recognized as key dimensions in hub location selection, and are represented by the Logistics Capacity (KL) criterion.

The six criteria therefore emerged as a synthesis of key concepts in the literature on disaster risk, social vulnerability, transportation networks, logistics distribution efficiency, and spatial planning and regulation. Each criterion has a conceptual foundation and is supported by empirical evidence, which provides a comprehensive and operational framework for assessing the suitability of candidate hub locations.

METHODOLOGY

This research uses a mixed-methods approach, combining qualitative exploration with quantitative AHP-based weighting, to obtain a deeper understanding of the main factors and the relationships among selection criteria based on the preferences of multiple actors (Creswell & Creswell, 2022). The research focuses on identifying key factors and their relationships in selecting locations for hydrometeorological disaster logistics hubs in West Java Province. To support the research's basic concept, a bibliometric analysis was conducted using VOSviewer and journal articles from Scopus and Publish or Perish (PoP) using the keywords “disaster logistics”, “logistics hub location”, “relief distribution”, “location-allocation model”, “disaster preparedness”, “AHP”, and “GIS-based decision making”, covering publications from 2015 to 2025

The bibliometric analysis was used to map research trends, main themes, and research gaps in disaster logistics and hub location studies, particularly those related to pre-disaster planning, hydrometeorological hazards, and multi-criteria decision-making. Using co-occurrence and density visualization, the results show that most previous studies focus on emergency response and technical optimization models. Only a small number of studies discuss spatial analysis, multi-actor preferences, and preparedness-based hub location planning. These findings support the need for qualitative research to explore important selection criteria and their relationships. Therefore, the proposed framework is based on both literature results and stakeholder perspectives.

The research area was selected using six main criteria derived from a literature review, policy analysis, and stakeholder input. These criteria include: high disaster risk, proximity to transportation hubs, availability of basic logistics facilities, fast access to densely populated areas, integration with regional and national logistics systems, and alignment with government disaster management plans. Based on these criteria, West Java Province was chosen because it frequently experiences floods, landslides, and extreme weather events, and because it has complex geographic conditions and a large population. The province is located between 5°50'–7°50' South Latitude and 104°48'–108°48' East Longitude. It includes both coastal and mountainous areas, which require a flexible, integrated disaster logistics system.

1. Aggregation and Consistency Assessment of Pairwise Judgments

Each institutional expert completed pairwise comparisons for the six primary criteria and for the sub-criteria within each criterion group using a 1–9 scale proposed by Saaty (2001). Before aggregation, the completeness and logical consistency of each respondent's pairwise-comparison matrices were examined using the Consistency Ratio (CR). A matrix was considered acceptable when CR was below 0.10 (Saaty & Vargas, 2012). Where a respondent's matrix exceeded this threshold, the respondent was asked to review and revise the relevant comparisons.

The judgments of the 12 respondents were subsequently aggregated using the Aggregation of Individual Judgments approach. For each pairwise-comparison element, the group judgment was calculated using the geometric mean:

$$a_{ij}^{G} = \left(\prod_{r=1}^{12} a_{ij}^{(r)} \right)^{1/12},$$

Where a_{ij}^{G} is the aggregated group judgment for the comparison between elements i and j, $a_{ij}^{(r)}$ is the judgment provided by respondent r, and 12 is the total number of institutional respondents. Priority weights were then derived from the aggregated matrices. The Consistency Ratio was recalculated for each aggregated matrix, including the primary-criteria matrix and all six sub-criteria matrices, to ensure that the collective judgments met the AHP consistency requirement.

The criteria used in this research were identified in several steps. First, an initial list of criteria was developed from a literature review, previous related studies, and a review of disaster management regulations and policies in West Java Province. The purpose of this stage was to compile a preliminary list representing the factors most relevant to the operational performance of hydrometeorological disaster logistics hubs.

The initial list was then examined and validated through expert judgment from multiple actors, including local governments, disaster management agencies, humanitarian organizations, logistics associations, and community representatives. This step ensured that the criteria and sub-criteria retained a theoretical foundation while remaining consistent with field conditions and operational needs.

Validation was conducted to ensure that the research is relevant, reliable, and appropriate for identifying selection criteria for disaster logistics hub locations. In this research, AHP was used to construct the decision hierarchy and assign weights through pairwise comparisons among elements. All criteria and sub-criteria were derived from relevant literature and previous studies and organized into a decision hierarchy to clarify the evaluation process.

Table 1. Criteria and SubCriteria

Criteria		Subcriteria	
KB	Disaster Vulnerability	KB1	Frequency of disaster events
		KB2	Regional risk level
		KB3	Population density level
		KB4	Critical infrastructure conditions
AK	Accessibility	AK1	Proximity to main road
		AK2	Proximity to distribution centers
		AK3	Accessibility during emergencies
		AK4	Availability of alternative modes of transportation
IN	Infrastructure	IN1	Availability of road network
		IN2	Access to communication and information
		IN3	Availability of supporting facilities
		IN4	Availability of electricity and clean water
PT	Affected Population	PT1	Proximity to densely populated areas
		PT2	Potential number of beneficiaries
		PT3	Level of socio-economic vulnerability of the community
DK	Policy Support	DK1	Included in the Regional Spatial Planning Plan (RTRW) for regional disasters
		DK2	Availability of government-owned land
		DK3	Land use permit status
KL	Logistics Capacity	KL1	Proximity to logistics warehouse

Criteria	Subcriteria	
	KL2	Availability of logistics and volunteer personnel
	KL3	Ease of aid mobilization and distribution

Table 1 present all criteria and subcriteria were determined based on relevant literature reviews and previous studies, then organized into a decision hierarchy structure to facilitate the assessment process. This hierarchy consists of three levels: Level 1 represents the main goal, which is to determine the best location for a disaster logistics hub; Level 2 contains the main criteria; Level 3 includes the sub-criteria. The proposed hierarchical model is presented in Figure 1.

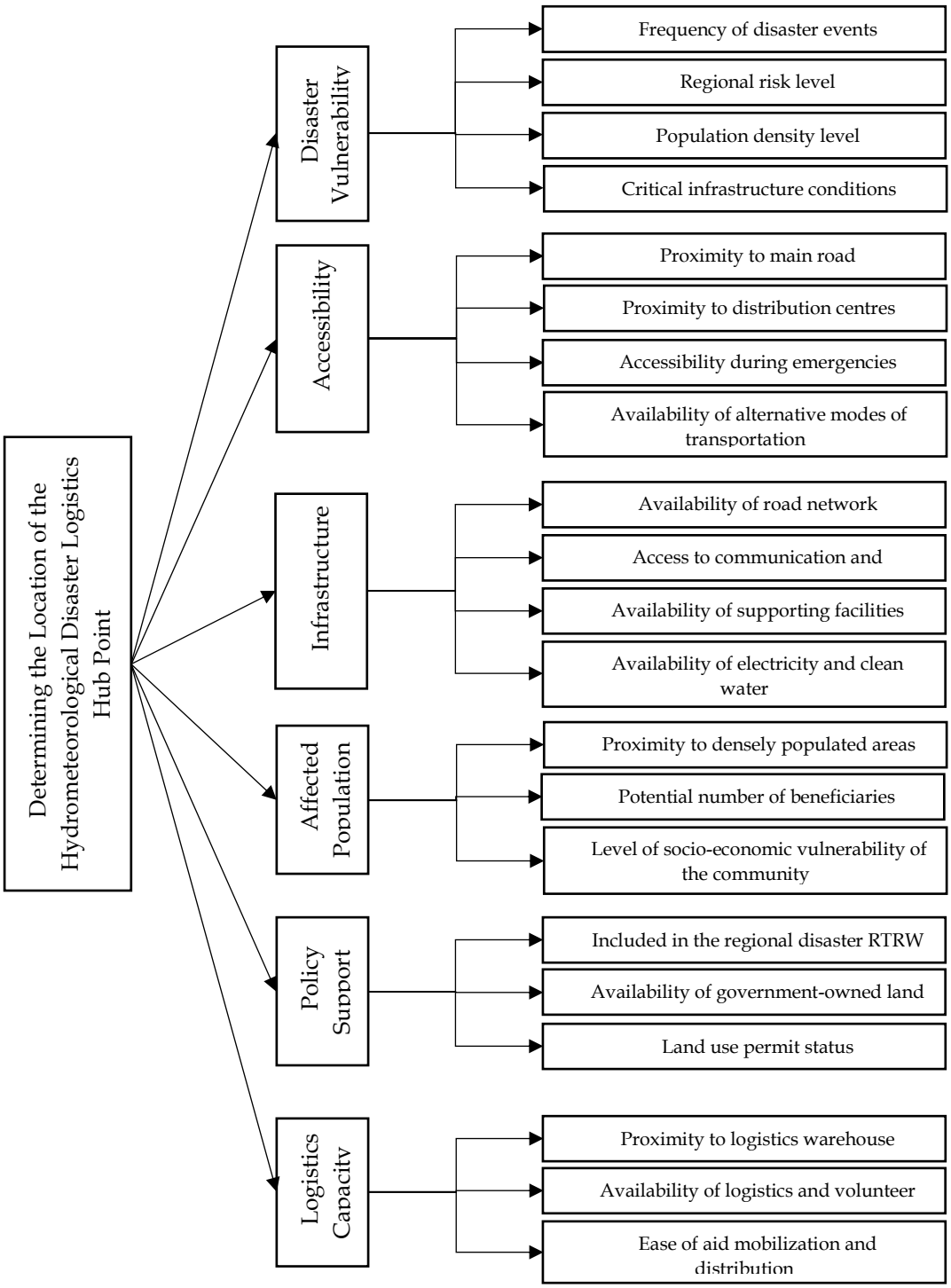

Figure 1. Research hierarchical structure

The validation process comprised multi-actor expert judgment and an AHP consistency assessment. Expert judgment was used to assess whether the proposed criteria, sub-criteria, and decision hierarchy were relevant, clearly defined, and practically applicable based on the perspectives of stakeholders involved in disaster management and logistics. The consistency of the aggregated pairwise-comparison matrix was evaluated using the Consistency Ratio (CR), with a value below 0.10 considered acceptable. These procedures ensured that the final criteria reflected both field-based stakeholder considerations and mathematically consistent pairwise judgments.

2. Expert Respondent Population and Selection

The institutional respondent population was defined based on the membership and functional responsibilities specified in West Java Governor Decree No. 380/Kep.627-BPBD/2022 concerning the West Java Provincial Disaster Management Logistics Cluster (Government of West Java, 2022). The research focused on actors assigned to, or directly associated with, the Storage and Maintenance and Transportation and Distribution functions because these two operational areas are the most directly related to logistics hub location decisions. The Storage and Maintenance function concerns the availability, condition, and readiness of relief supplies and storage facilities, whereas the Transportation and Distribution function concerns distribution routes, transport modes, accessibility, and the mobilization of relief supplies.

Based on this operational definition, the target institutional population comprised 12 organizations with the most direct responsibilities and field experience relevant to disaster logistics hub planning. All 12 organizations were included in the research; therefore, no sampling procedure was applied. The research employed a complete enumeration, or census, of the defined institutional population. Each organization was represented by one expert holding a managerial or operational role related to disaster logistics, storage, transportation, distribution, infrastructure, or humanitarian response.

The respondent population comprised Perum Bulog West Java, the West Java branch of the Indonesian Logistics and Forwarders Association (ALFI), the West Java Provincial Transportation Agency, the West Java Regional Office of the Directorate General of Customs and Excise, PT Pos Indonesia Regional 3 West Java, PT Kereta Api Indonesia Operational Area II, PT Angkasa Pura II Bandung Branch, the West Java branch of the Indonesian Trucking Association (Aptrindo), the West Java branch of the Indonesian Express Delivery Companies Association (Asperindo), Muhammadiyah Disaster Management Center West Java, Korpri West Java, and the West Java Joint Disaster Preparedness Post. Two institutional actors represented the Storage and Maintenance function, while ten represented the Transportation and Distribution function. The population included government agencies, state-owned logistics and transportation enterprises, professional logistics associations, and humanitarian organizations.

RESULT AND DISCUSSION

Result

The bibliometric mapping shows that research in disaster logistics management has grown a lot in the last ten years (2015–2025). The co-occurrence map shows four main focus areas. These are studies on choosing facility locations (hub location and facility placement), disaster types and their characteristics, different disaster phases (before, during, and after), and analytical methods. The results also show that research on the pre-disaster phase remains quite limited, especially studies that combine spatial analysis, multi-criteria evaluation, and fuzzy methods within an integrated model. Most research still focuses more on the emergency response phase than on preparedness planning.

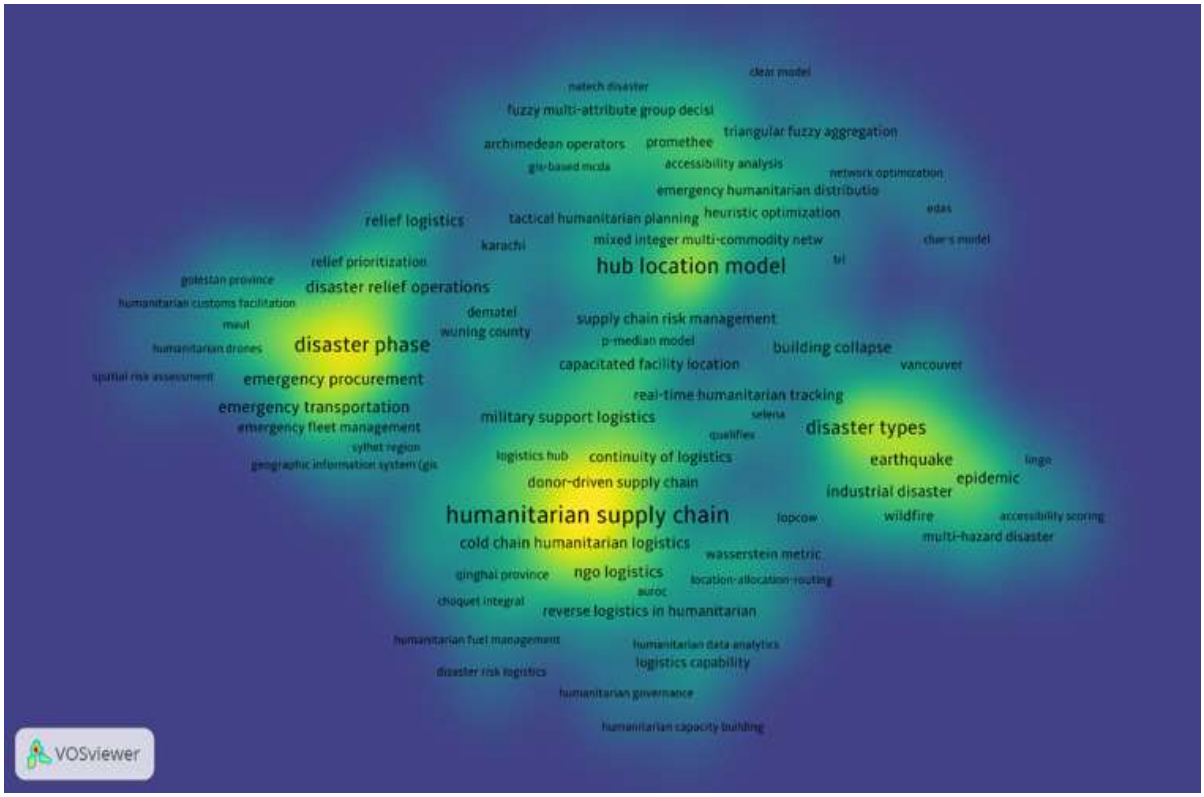

Figure 2. Visualization of Density Map of Humanitarian Supply Chain and Hub Location Model (Source: VOSviewer, 2025)

Figure 2 shows that global research on humanitarian logistics is mostly focused in the models and humanitarian supply chains. This means these two topics are the main focus of existing studies. The green area around it shows related studies, but they are still not strongly connected into one clear method or approach. Meanwhile, the blue and dark blue areas on the map, which represent topics like hydrometeorological disasters and the pre-disaster (preparedness) phase, have low density and very little research attention. This pattern shows that these topics are still not explored much in scientific studies. This density map confirms that this research has strong novelty because it looks at an area that is still rarely studied, especially in terms of disaster type, combined methods, and focus on the pre-disaster phase. This can be clearly seen in the emerging research zone on the map.

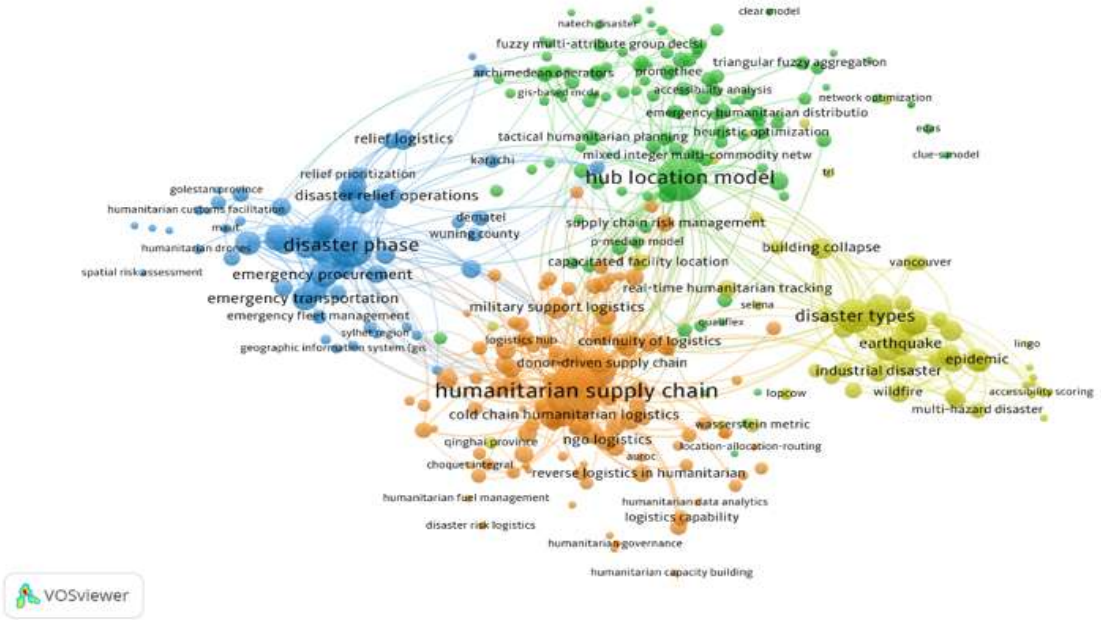

Figure 3. Visualization Co-Occurrence Network on Humanitarian Supply Chain and Hub Location Model (Source: VOSviewer, 2025)

The co-occurrence map in Figure 3 shows that keywords in humanitarian logistics research are connected and form several theme groups. There are four main clusters linked by two central keywords: "humanitarian supply chain" and "hub location model," which work as bridges between different topics. The green cluster (top–center) includes themes related to mathematical and analytical methods, such as the p-median model, capacitated facility location, mixed-integer optimization, triangular fuzzy methods, PROMETHEE, and accessibility analysis. The strong connections among these keywords indicate that many studies focus on technical approaches to hub design and logistics network optimization. However, each method seems to remain in its own small group, so the methods are still separated and not well integrated. The yellow cluster (right) contains themes related to disaster types such as earthquakes, industrial disasters, epidemics, wildfires, and building collapses. These keywords are strongly linked with the technical methods cluster, showing that most hub location models were developed for geological or man-made disasters. However, keywords such as flood, storm, or hydrometeorological disaster do not appear clearly, which means climate-related disasters are still not a main focus in previous studies. This opens a new research area for climate-based hazards.

The blue cluster (left) is related to disaster and emergency operation phases, including the disaster phase, emergency procurement, emergency transportation, disaster relief operations, and relief logistics. The strong links between these keywords show that most research concentrates on emergency response (during disasters). There are almost no strong links to topics of mitigation or preparedness, indicating that the pre-disaster phase is still rarely studied in disaster logistics research. The orange cluster (bottom) focuses on supply chain management and organizational issues, including logistics continuity, NGO logistics, reverse logistics in humanitarian work, and cold chain logistics. This cluster connects emergency operations (blue) with analytical methods (green). However, it also shows that research mostly focuses on response and coordination rather than on risk analysis or planning before disasters occur.

Studies by Yılmaz & Kabak (2020), Huang et al. (2022), and Geng et al. (2020) mainly focus on post-disaster management and evaluation, while research by Liu et al. (2022) and Rye & Aktas (2022) discuss responses during the crisis phase. There are almost no studies that clearly focus on the pre-disaster phase, especially on the importance of preparedness and risk reduction before a disaster happens. This shows that research attention remains uneven across disaster phases, with very limited focus on prevention and on strengthening preparedness systems, including selecting strategic logistics locations before disasters occur. Therefore, this research takes an important position by seeking to fill this gap by focusing on the pre-disaster phase, especially in selecting locations for disaster logistics hubs.

This research presents the results of weighting the criteria and sub-criteria for selecting hydrometeorological disaster logistics hub locations in West Java Province using the Analytical Hierarchy Process (AHP) method. The analysis aims to determine the relative importance of each factor in influencing location decisions, based on expert opinions. The weights are obtained from a pairwise comparison matrix that has passed the consistency test, so the results can be reasonably trusted. The discussion then focuses on explaining the meaning of these weights and what they imply for choosing the best location for the logistics hub.

This validation was conducted through a multi-actor expert judgment approach, gathering input from experts and stakeholders directly involved in the disaster logistics network. This multi-actor involvement ensured that the validation process reflected a variety of perspectives, from storage, transportation, distribution, to operational support in the field.

1. Validation of Disaster Vulnerability Criteria and Subcriteria

The Disaster Vulnerability (KB) criteria were validated using views from actors directly involved in logistics management, aid distribution, and disaster response in West Java. All informants said that choosing the location of logistics hubs is strongly related to past disaster patterns and geographic locations of disasters in the region (KB1). Not only how often disasters occur, but also the regional risk level (KB2) was confirmed as an important factor to be considered alongside logistics operations. Disaster vulnerability was identified as a fundamental and important factor in determining logistics hub locations because it directly affects people, critical infrastructure, and the continuity of logistics operations during disasters. Population density (KB3) was found to increase disaster impact and complicate distribution, especially when combined with damaged infrastructure, as shown in the Cianjur case and supported by MDMC and the Disaster Preparedness Post (Posgab Siaga Bencana).

Although critical infrastructure conditions were frequently emphasised during the qualitative validation, the aggregated AHP judgments assigned the highest local weight to regional risk level (0.32). Disaster frequency and population density each received a weight of 0.24, while critical infrastructure conditions received a weight of 0.20. This difference shows that the frequency with which an issue was mentioned qualitatively should not be interpreted as equivalent to its relative priority in the pairwise-comparison results. Overall, disaster vulnerability remains an important criterion because it influences both potential humanitarian demand and the continuity of logistics operations, although its sub-criteria have different relative priorities in the multi-actor assessment.

2. Validation of Accessibility Criteria and Subcriteria

The Accessibility (AK) criterion was validated by actors from government agencies, logistics companies, transport operators, and humanitarian organizations directly involved in aid distribution in West Java. The qualitative validation confirmed the relevance of all four accessibility sub-criteria. Proximity to main roads (AK1) was repeatedly identified by representatives of Bulog West Java, the West Java Provincial Transportation Agency, Pos Indonesia, and the West Java Korpri Secretariat as a basic requirement for rapid and reliable aid distribution. Proximity to distribution centres (AK2) was also considered important because logistics hubs need to be connected to existing supply nodes, including Bulog warehouses, postal facilities, type-B terminals, and customs facilities. Emergency accessibility (AK3) and the availability of alternative transportation modes (AK4) were emphasised because conventional distribution routes may be blocked or unavailable during severe disaster conditions.

Although proximity to main roads was prominently discussed during the qualitative validation, the aggregated AHP results assigned the highest local weight to proximity to distribution centres (AK2 = 0.31). Emergency accessibility (AK3) and the availability of alternative transportation modes (AK4) each received a weight of 0.25, while proximity to main roads (AK1) received the lowest relative weight of 0.19. This difference indicates that the qualitative prominence of main-road access reflects its role as a basic operational requirement rather than its position as the highest AHP priority. Overall, the results show that accessibility is understood not merely as proximity to a major road, but as a broader combination of connectivity to supply nodes, emergency reachability, and transport-mode redundancy. Accordingly, all four accessibility sub-criteria were retained in the AHP hierarchy.

3. Validation of Infrastructure Criteria and Subcriteria

The Infrastructure (IN) criterion was confirmed as a very important factor in determining how well disaster logistics hubs function in West Java. Many actors said that the region's physical readiness directly affects how smoothly aid distribution can be. The qualitative validation confirmed the relevance of all four Infrastructure (IN) sub-criteria. The availability and condition of road networks (IN1) were strongly emphasised because road access determines whether relief supplies can reach and leave the hub, particularly when disasters disrupt normal transport conditions. Access to communication and information (IN2) was also considered essential for operational coordination, rapid decision-making, and the continuity of aid distribution. Supporting facilities (IN3), including warehouses, transport nodes, and other operational facilities, were widely recognised as necessary for receiving, storing, and distributing relief supplies. The availability of electricity and clean water (IN4) was emphasised as a basic requirement for maintaining logistics facilities, evacuation posts, communication systems, and aid coordination during emergencies.

Although road networks and supporting facilities were prominently discussed during the qualitative validation, the aggregated AHP results assigned the highest local weight to the availability of electricity and clean water (IN4 = 0.32). The availability of the road network (IN1) received a weight of 0.28, while access to communication and information (IN2) and the availability of supporting facilities (IN3) each received a weight of 0.20. This difference indicates that the qualitative prominence of a sub-criterion should not be interpreted as equivalent to its relative priority in the aggregated pairwise-comparison results. The highest weight assigned to electricity and clean water highlights the importance of basic utility continuity in ensuring that a logistics hub remains operational even when other infrastructure systems are disrupted. Accordingly, all four Infrastructure sub-criteria were retained in the AHP hierarchy, but with different relative priorities.

4. Validation of the Affected Population Criterion and Sub-criteria

The Affected Population (PT) criterion was strongly validated by actors with direct experience in disaster logistics and humanitarian response in West Java. Proximity to densely populated areas (PT1) was considered important

because areas with high population concentrations may generate larger evacuation requirements and greater demand for relief supplies. The potential number of beneficiaries (PT2) was also recognised as a key consideration for estimating the quantity of aid required, allocating logistics resources, and determining transport and fleet capacity. Socio-economic vulnerability (PT3) was considered relevant because economically and socially vulnerable communities may face greater difficulties in accessing assistance and may experience more severe consequences when relief distribution is delayed.

The aggregated AHP results were consistent with the qualitative validation. Proximity to densely populated areas (PT1) received the highest local weight of 0.37, closely followed by the potential number of beneficiaries (PT2) at 0.35, while socio-economic vulnerability (PT3) received a weight of 0.28. The small difference between PT1 and PT2 indicates that the actors considered both the spatial concentration of humanitarian demand and the estimated scale of beneficiaries to be central to hub-location planning. Although PT3 received the lowest relative weight within this criterion, it remains important for ensuring that location decisions consider not only the number of people potentially served but also differences in their capacity to cope with and recover from disaster impacts. Accordingly, all three Affected Population sub-criteria were retained in the AHP hierarchy.

5. Validation of Policy Support Criteria and Subcriteria

The Policy Support (DK) criterion was strongly validated by government agencies, logistics operators, transport institutions, and humanitarian organizations involved in disaster logistics in West Java. The actors emphasised that a logistics hub requires a clear institutional and legal basis to ensure that it can be established, activated, and operated without regulatory or land-related obstacles. Alignment with disaster-related spatial planning (DK1) was considered essential because a proposed hub location must comply with the applicable spatial plan and should not be situated in a restricted or incompatible land-use zone. The availability of government-owned land (DK2) was also regarded as relevant because it can reduce land-acquisition difficulties, minimise potential social conflict, and facilitate rapid facility activation. Land-use permit status (DK3) was validated as an important administrative requirement for ensuring legal certainty and supporting the movement, receipt, storage, and distribution of relief supplies.

The aggregated AHP results assigned the highest local weight to alignment with disaster-related spatial planning (DK1 = 0.41), followed by land-use permit status (DK3 = 0.30) and the availability of government-owned land (DK2 = 0.29). These results indicate that formal spatial-planning conformity was considered more important than land ownership alone. Although government-owned land may accelerate activation and reduce potential conflict, the land must first be located within an appropriate spatial designation and supported by clear permission for logistics operations. The relatively close weights of DK2 and DK3 further show that land availability and legal permission are complementary requirements. Accordingly, all three Policy Support sub-criteria were retained in the AHP hierarchy, with DK1 representing the principal institutional condition for converting a technically suitable site into a legally and operationally implementable disaster logistics hub.

6. Validation of the Logistics Capacity Criterion and Sub-criteria

The Logistics Capacity (KL) criterion was strongly validated based on the real-world experience of government, private-sector, and humanitarian logistics actors. Proximity to logistics warehouses (KL1) was considered important because connections with existing storage and supply facilities can shorten response times, support stock availability, and facilitate the movement of relief supplies. The availability of logistics staff and volunteers (KL2) was also recognised as necessary because trained personnel, institutional staff, logistics operators, and locally knowledgeable volunteers enable operations to respond more flexibly to changing field conditions. Ease of aid mobilization and distribution (KL3) was emphasised as a central operational requirement because relief supplies must be moved rapidly through coordinated institutions, suitable transport modes, and routes that remain usable or can be adapted during emergencies.

The aggregated AHP results assigned the highest local weight to ease of aid mobilization and distribution (KL3 = 0.41), followed by proximity to logistics warehouses (KL1 = 0.32) and the availability of logistics staff and volunteers (KL2 = 0.27). The priority assigned to KL3 indicates that logistics capacity was understood primarily in terms of the ability to mobilize and distribute relief supplies rapidly and flexibly. The weight assigned to KL1 confirms the importance of connecting proposed hubs with existing logistics stocks and storage nodes, whereas KL2 reflects the human-resource capacity required to operate those facilities and distribution networks. Accordingly, all three Logistics Capacity sub-criteria were retained in the AHP hierarchy, with KL3 representing the highest relative priority within this criterion.

Table 2. Validation of Criteria and Sub Criteria

Criteria	Subcriteria	Validation Conclusion	Validating Actor
Disaster Vulnerability (KB)	Frequency of disaster events (KB1)	The actor confirmed that floods, landslides, and earthquakes are recurring events in West Java. The hub's location must take into account historical disaster patterns.	Bulog, ALFI, Transportation Agency, Pos Indonesia, MDMC, Posgab
	Regional risk level (KB2)	The actors emphasized that several areas in West Java, especially South West Java and Karawang-Cianjur, have a highrisk level, so the hub location must be in a safe point but still close to vulnerable areas.	Bulog, ALFI, Transportation Agency, Asperindo, MDMC
	Population density (KB3)	The actor explained that density magnifies the impact of disasters, increases the number of victims, and influences the priority of aid distribution (e.g., Cianjur Earthquake).	Pos Indonesia, ALFI, MDMC
	Critical infrastructure conditions (KB4)	Nearly all actors validated that damaged roads, bridges, and disrupted access were major obstacles to logistics distribution. Critical infrastructure determines the feasibility of hub locations.	Bulog, Asperindo, Aptrindo, MDMC, Posgab, Transportation Agency
Accessibility (AK)	Proximity to main road (AK1)	All logistics actors emphasize the importance of hub proximity to national/provincial roads for fast and unimpeded distribution.	ALFI, Aptrindo, Bulog, Pos Indonesia, KAI, DJBC
	Proximity to distribution center (AK2)	Validation arises from logistics actors who require connectivity to large distribution centers such as Bulog warehouses, sorting centers, goods terminals, and dry ports.	Bulog, ALFI, Pos Indonesia, DJBC
	Emergency Accessibility (AK3)	Disaster actors described on-the-ground conditions where access is often cut off during disasters. Hub locations must remain accessible during emergencies.	MDMC, Posgab, Bulog, Asperindo
	Alternative modes of transportation (AK4)	Actors such as Pos Indonesia, KAI, and Angkasa Pura emphasized the importance of alternative transportation options (trains, dirt bikes, planes) when land routes are impassable.	KAI, Angkasa Pura II, Pos Indonesia, ALFI, DJBC
Infrastructure (IN)	Road network availability (IN1)	The actor highlighted the need for connecting roads that are strong, not easily damaged, and allow the mobilization of large vehicles.	Transportation Agency, Aptrindo, Asperindo, ALFI, DJBC
	Access to communication and information (IN2)	Strong validation from disaster actors emphasizing the importance of signals/communication for distribution coordination and tracking.	MDMC, Posgab, Pos Indonesia
	Availability of supporting facilities (IN3)	Warehouses, operational offices, parking areas, and loading and unloading facilities are prerequisites for hub locations according to logistics practitioners.	Bulog, Pos Indonesia, ALFI, DJBC
	Electricity and clean water (IN4)	Required to run storage facilities, heavy equipment, record keeping, and daily operational support of the hub.	Bulog, MDMC, ALFI
Affected Population (PT)	Proximity to densely	The actor emphasized that the hub location must be able to reach densely populated	Pos Indonesia, ALFI, MDMC

Criteria	Subcriteria	Validation Conclusion	Validating Actor
	populated areas (PT1)	areas that are frequently affected by disasters.	
	Potential number of beneficiaries (PT2)	Validation shows that hubs should be located near areas with a large number of potential beneficiaries for faster distribution.	Bulog, ALFI, MDMC
	Socio-economic vulnerability (PT3)	Humanitarian actors and governments have highlighted that poor and vulnerable groups require distribution priority, so hub locations must consider the distribution of vulnerable groups.	MDMC, Posgab, Dishub
Policy Support (DK)	RTRW Compliance (DK1)	Government actors explained that the location of the hub must be in line with the RTRW so that it does not violate spatial allocation or be located in a prohibited zone.	Transportation Agency, Bulog, DJBC
	Availability of government land (DK2)	Validation emphasizes that government-owned land facilitates hub development, avoids land conflicts, and expedites legality.	Bulog, Transportation Agency, DJBC
	Land use permit status (DK3)	The actor mentioned the need for clear operating permits so that aid distribution can be carried out without regulatory obstacles, especially in emergency situations.	Bulog, ALFI, Transportation Agency, DJBC
Logistics Capacity (KL)	Proximity to logistics warehouse (KL1)	The actor emphasized that Bulog warehouses, postal warehouses, train depots, and airport warehouses are the main nodes that must be close to the hub location.	Bulog, Pos Indonesia, KAI, Angkasa Pura II, ALFI, DJBC
	Availability of logistics personnel & volunteers (KL2)	Actors from ALFI, Pos Indonesia, MDMC, and Korpri emphasized the importance of logistics human resources, local volunteers, and the organization's ability to mobilize personnel quickly.	ALFI, MDMC, Korpri, Pos Indonesia
	Ease of mobilization of aid & distribution (KL3)	Distribution is often hampered by traffic jams, broken lines, or coordination. Hub locations must allow for rapid mobilization, cross-modal integration, and bottleneck-free distribution.	Aptrindo, ALFI, MDMC, Posgab, Pos Indonesia, KAI, DJBC

Source: Research Data Processing Results (2025)

Based on the validation results, a decision hierarchy structure was developed using the AHP method, consisting of four levels: Level 1 contains the main research objectives, Level 2 contains the main criteria, and Level 3 includes sub-criteria that elaborate on each criterion. This hierarchical structure serves as the basis for the weighting and assessment processes carried out in the subsequent analysis stages.

1. Calculation of Hierarchical Weighting Factors for Primary Criteria

Table 3 presents the priority weights derived from the aggregated pairwise-comparison judgments of all 12 institutional experts. The respondents represented the complete institutional population defined for this research rather than a sample. Their individual judgments were aggregated element by element using the geometric mean before the group priority vector was calculated. The aggregated primary-criteria matrix satisfied the AHP consistency requirement, with a Consistency Ratio of 0.036, reported as 0.04 after rounding.

Table 3. Recapitulation of Main Criteria Weights

No	Criteria	Code	Weight
1	Disaster Vulnerability	KB	0.10
2	Accessibility	AK	0.20
3	Infrastructure	IN	0.17
4	Affected Population	PT	0.18
5	Policy Support	DK	0.21
6	Logistics Capacity	KL	0.15

Based on the AHP result, policy support (DK) has the highest weight with value 0.21. This means regulation, spatial suitability, and land legality are the most important factors in choosing the location of a hydrometeorological disaster logistics hub. Accessibility (AK) has weight 0.20 and affected population (PT) has weight 0.18, which shows that easy access and many people to be served are also very important for good aid distribution. Infrastructure (IN) gets weight 0.17, showing that supporting facilities and infrastructure are important for logistics activities. Logistics capacity (KL) has weight 0.15, while disaster vulnerability (KB) is the lowest with weight 0.10. The lower relative weight of Disaster Vulnerability does not indicate that disaster risk is unimportant; rather, it suggests that hazard exposure must be balanced with institutional feasibility, accessibility, and the ability of the hub to remain operational during an emergency. The weighting result can be trusted because the pairwise comparison matrix passed the consistency test with Consistency Ratio (CR) value 0.04, which is below 0.1.

2. Calculation of Hierarchical Weighting Factors for Sub-Criteria

a. Disaster Vulnerability Sub-Criteria

The weighting of these sub-criteria aims to identify the vulnerability aspects that most influence the effectiveness of disaster response and distribution of aid.

Table 4. Disaster Vulnerability Sub-Criteria

Code	Subcriteria	Weight
KB1	Frequency of disaster events	0.24
KB2	Regional risk level	0.32
KB3	Population density level	0.24
KB4	Critical infrastructure conditions	0.20

Based on Table 4, the regional risk level sub-criteria (KB2) has the highest weighting of 0.32, indicating that the regional risk level is a primary consideration in the disaster vulnerability aspect. The sub-criteria for disaster frequency (KB1) and population density (KB3) have the same weighting of 0.24 each, while the condition of critical infrastructure (KB4) has the lowest weighting of 0.20, indicating its role as a supporting factor in the disaster vulnerability group.

b. Accessibility Sub-Criteria

The accessibility sub-criterion is used to assess the ease of reaching logistics hub locations, both under normal conditions and during disasters. This aspect is crucial because it directly impacts the speed of aid mobilization and the smooth distribution of logistics to affected areas.

Table 5. Accessibility Sub-Criteria

Code	Subcriteria	Weight
AK1	Proximity to main road	0.19
AK2	Proximity to distribution centers	0.31
AK3	Accessibility during emergencies	0.25
AK4	Alternative modes of transportation	0.25

Based on the table above, the sub-criterion of proximity to distribution centers (AK2) has the highest weighting of 0.31, indicating that connectivity to logistics distribution centers is the most dominant factor in the accessibility aspect. The sub-criteria of emergency accessibility (AK3) and the availability of alternative

transportation modes (AK4) have the same weighting of 0.25 each, while proximity to main roads (AK1) has the lowest weighting of 0.19.

c. Infrastructure Sub-Criteria

Table 6. Infrastructure Sub-Criteria

Code	Subcriteria	Weight
IN1	Availability of road network	0.28
IN2	Access to communication and information	0.20
IN3	Availability of supporting facilities	0.20
IN4	Availability of electricity and clean water	0.32

Based on the table above, the sub-criterion of electricity and clean water availability (IN4) has the highest weighting of 0.32, indicating that the sustainability of basic utilities is the most important factor in supporting logistics hub operations. The sub-criterion of road network availability (IN1) has a weighting of 0.28, while communication and information access (IN2) and the availability of supporting facilities (IN3) have the same weighting, each at 0.20.

d. Sub-Criteria for Affected Population

The affected population sub-criteria is used to describe the potential beneficiaries of a disaster logistics hub. This aspect is crucial to ensure that the selected location can reach areas with high levels of aid need.

Table 7. Sub Criteria Affected Population

Code	Subcriteria	Weight
PT1	Densely populated areas	0.37
PT2	Potential number of beneficiaries	0.35
PT3	Socio-economic vulnerability	0.28

Based on the table above, the sub-criterion of proximity to densely populated areas (PT1) has the highest weighting of 0.37, indicating that population concentration is a major factor in determining location. The sub-criterion of potential beneficiaries (PT2) has a weighting of 0.35, while the level of socioeconomic vulnerability (PT3) has the lowest weighting of 0.28.

e. Policy Support Sub-Criteria

Table 8. Policy Support Sub-Criteria

Code	Subcriteria	Weight
DK1	Entering the disaster RTRW	0.41
DK2	Availability of government land	0.29
DK3	Land permit status	0.30

Based on the table above, the sub-criterion for inclusion in the disaster-related spatial planning (DK1) has the highest weighting of 0.41, indicating that compliance with spatial planning is the most crucial factor in policy aspects. The sub-criterion for land permit status (DK3) has a weighting of 0.30, while the availability of government-owned land (DK2) has a weighting of 0.29.

f. Logistic Capacity Sub-Criteria

Table 9. Logistic Capacity Sub-Criteria

Code	Subcriteria	Weight
KL1	Proximity to logistics warehouse	0.32
KL2	Logistics staff and volunteers	0.27
KL3	Ease of mobilization of aid	0.41

Based on Table 9, the sub-criterion of ease of aid mobilization (KL3) has the highest weighting of 0.41, indicating that speed and smooth distribution are the most dominant factors in logistics capacity. The sub-criterion of proximity to logistics warehouses (KL1) has a weighting of 0.32, while the availability of logistics personnel and volunteers (KL2) has the lowest weighting of 0.27.

3. Consistency Ratios of the Aggregated Pairwise-Comparison Matrices

To assess the logical consistency of the collective judgments, the Consistency Ratio (CR) was calculated for the aggregated pairwise-comparison matrix of the primary criteria and for each sub-criteria matrix. The results are presented in Table 10.

Table 10. Consistency Ratios of the Aggregated Pairwise-Comparison Matrices

Pairwise-Comparison Matrix	Number of Elements	Consistency Ratio (CR)	Assessment
Primary criteria	6	0.036	Consistent
Disaster Vulnerability sub-criteria	4	0.016	Consistent
Accessibility sub-criteria	4	0.010	Consistent
Infrastructure sub-criteria	4	0.028	Consistent
Affected Population sub-criteria	3	0.014	Consistent
Policy Support sub-criteria	3	0.012	Consistent
Logistics Capacity sub-criteria	3	0.005	Consistent

As shown in Table 10, the Consistency Ratios of the aggregated primary-criteria and sub-criteria matrices ranged from 0.005 to 0.036. All values were below the maximum acceptable threshold of 0.10, indicating that the aggregated multi-actor judgments were logically consistent and suitable for deriving the final priority weights.

Discussion

1. Interpretation of the Aggregated AHP Weights

The AHP results indicate that the selection of hydrometeorological disaster logistics hub locations in West Java is shaped by a relatively balanced combination of institutional, operational, social, and risk-related considerations. Policy Support received the highest weight (0.21), followed closely by Accessibility (0.20), Affected Population (0.18), Infrastructure (0.17), Logistics Capacity (0.15), and Disaster Vulnerability (0.10). The narrow difference between Policy Support and Accessibility is particularly important because it indicates that institutional feasibility and physical connectivity are complementary rather than competing requirements. A location may be accessible from a transport perspective, but it cannot function effectively as a logistics hub unless its use is supported by spatial planning, land legality, and the relevant institutional arrangements.

2. Empirical Research Related to Logistics Hub Locations

Previous humanitarian facility-location studies have generally identified accessibility as the dominant consideration, particularly proximity to main roads, transport nodes, demand centres, and the minimisation of distribution time (Feng et al., 2023; Erden et al., 2024; Yılmaz & Kabak, 2024). The present results broadly support this literature because Accessibility was assigned the second-highest weight (0.20), only 0.01 below Policy Support. Within the Accessibility criterion, proximity to distribution centers received the highest local weight (0.31), followed by emergency accessibility and the availability of alternative transport modes, each with a weight of 0.25, while proximity to main roads received a weight of 0.19. This pattern extends the conventional understanding of accessibility beyond simple road proximity. For the participating actors, accessibility also concerns connectivity with existing supply nodes, the ability to maintain access under disrupted conditions, and the availability of alternative modes when conventional routes cannot be used.

The slightly higher weight assigned to Policy Support represents the most distinctive finding of this research. It does not contradict accessibility-oriented facility-location research; rather, it shows that physical connectivity alone is insufficient in the West Java pre-disaster planning context. A technically accessible site may remain unusable when it is inconsistent with spatial plans, located in a restricted zone, subject to unresolved land status, or unsupported by the relevant administrative authority. Previous studies have acknowledged that regulatory clarity, government support, and stakeholder involvement affect the implementation of humanitarian facility-location decisions (King et al., 2016; Rodríguez-Espíndola et al., 2023; Carnero Quispe et al., 2024). The present findings move these considerations from external implementation conditions into the formal location-selection structure.

The local weights within Policy Support clarify why this criterion marginally exceeded Accessibility. Inclusion in disaster-related spatial planning received the highest local weight (0.41), followed by land-use permit status (0.30) and the availability of government-owned land (0.29). These priorities indicate that institutional feasibility is not external to location suitability but forms one of its central dimensions. Spatial-plan recognition provides a formal basis for facility development, clear permits reduce administrative uncertainty, and government-owned land can shorten activation procedures and reduce potential land conflicts. Policy Support can therefore be interpreted as an enabling condition that converts an accessible candidate site into a legally and operationally deployable logistics hub.

CONCLUSION

This research developed and validated a three-level, multi-actor criteria framework for evaluating hydrometeorological disaster logistics hub locations in West Java. The framework comprises one decision objective, six main criteria, and 21 sub-criteria. Policy Support received the highest global weight (0.21), narrowly exceeding Accessibility (0.20), followed by Affected Population (0.18), Infrastructure (0.17), Logistics Capacity (0.15), and Disaster Vulnerability (0.10). All aggregated pairwise-comparison matrices met the acceptable consistency requirement. The highest local priorities within the six criteria were regional risk level (KB2 = 0.32), proximity to distribution centres (AK2 = 0.31), availability of electricity and clean water (IN4 = 0.32), proximity to densely populated areas (PT1 = 0.37), alignment with disaster-related spatial planning (DK1 = 0.41), and ease of aid mobilisation and distribution (KL3 = 0.41). The narrow difference between Policy Support and Accessibility demonstrates that institutional implement ability is not secondary to technical connectivity; rather, spatial-planning conformity, legal certainty, land availability, and administrative authority determine whether an accessible site can be operationalised as a disaster logistics hub.

Conceptually, the research contributes a pre-disaster and multi-actor framework that distinguishes the validation of criteria from their relative prioritisation and clarifies why qualitative prominence does not necessarily correspond to the highest AHP weight. Practically, the framework provides government agencies, logistics operators, and humanitarian organisations with a transparent basis for screening candidate sites, aligning hub planning with spatial and land-use policies, and incorporating access to distribution centres, multimodal connectivity, utility continuity, beneficiary coverage, and mobilisation capacity into subsequent location assessments. However, the findings reflect the institutionally bounded preferences of the 12 participating actors and do not yet identify or rank candidate locations; consequently, sensitivity analysis was not conducted at this stage. Future research should integrate the validated weights with GIS-based hazard, population, infrastructure, accessibility, and land-use data; define and rank explicit candidate sites; test the stability of the results through sensitivity and scenario analyses; and broaden participation to include district- or municipal-level actors and affected communities. Until these stages are completed, the framework should be used as a basis for pre-disaster screening and model development rather than as a final investment or site-designation decision.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE MANUSCRIPT PREPARATION PROCESS.

During the preparation of this work, the authors used OpenAI to assist with language editing, improve clarity and academic writing style, refine the organization of selected manuscript sections, and support the cross-checking and consistency review of citations and references. The tool was not used to collect or generate research data, perform the AHP calculations, determine criteria weights, independently interpret the empirical findings, or formulate the study's conclusions. After using this tool, the authors carefully reviewed, verified, and edited all AI-assisted content, including factual statements, numerical results, citations, and bibliographic

information. The authors take full responsibility for the accuracy, integrity, originality, and final content of the published article.

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