SPATIAL IDENTIFICATION OF CRITICAL LOGISTICS INFRASTRUCTURE AS NATIONAL VITAL OBJECTS: A NETWORK RESILIENCE APPROACH TO MEGATHRUST CONTINGENCIES

IDENTIFIKASI SPASIAL INFRASTRUKTUR LOGISTIK KRITIS SEBAGAI OBJEK VITAL NASIONAL: PENDEKATAN KETAHANAN JARINGAN TERHADAP KONTINJENSI MEGATHRUST

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Abstract – The looming threat of a Megathrust earthquake and tsunami along the southern coast of Java compromises not only human safety but also the operational readiness of regional defense and national security. While existing literature predominantly focuses on outbound evacuation flows, there is a critical gap in assessing the resilience of inbound logistics supply chains essential for emergency response operations. This study aims to identify strategic road segments qualifying as National Vital Objects and to delineate isolated territories necessitating Military Operations Other Than War (MOOTW). By employing a spatial network science approach, specifically utilizing Betweenness Centrality algorithms and Network Robustness simulations within the Palabuhanratu road network, this research models the systemic breakdown of access under tsunami inundation scenario, by applying a binary failure threshold of flow depth h_{max} > 0.3m. The quantitative analysis identifies "Jalan Lintas Jabar Selatan" as the critical logistics backbone, exhibiting the highest vitality score of 0.19, representing the dominant outlier compared to other arterial corridors in the network. Concurrently, the hazard simulation reveals the formation of tactical isolation clusters in Citarik and Palabuhanratu, where 22.45% of the network nodes experience total access severance (cut-off). These findings underscore the strategic imperative for establishing joint contingency plans that integrate air-bridge and maritime access capabilities to ensure the continuity of national defense logistics during crisis contingencies.

Keywords: Betweenness Centrality, Disaster Logistics, MOOTW, Non-military Defense, National Vital Objects

Abstrak *– Ancaman gempa bumi megathrust dan tsunami yang membayangi pesisir selatan Jawa tidak hanya membahayakan keselamatan jiwa manusia, tetapi juga mengancam kesiapan operasional pertahanan wilayah dan keamanan nasional. Meskipun literatur yang ada saat ini didominasi oleh fokus pada arus evakuasi keluar (outbound), terdapat kesenjangan kritis dalam penilaian ketahanan rantai pasok logistik masuk (inbound) yang esensial bagi operasi tanggap darurat. Penelitian ini bertujuan untuk mengidentifikasi segmen jalan strategis yang memenuhi kualifikasi sebagai Objek Vital Nasional (Obvitnas) dan mendelineasi wilayah terisolasi yang memerlukan Operasi Militer Selain Perang (OMSP). Dengan menggunakan pendekatan sains jaringan spasial, khususnya algoritma Betweenness Centrality dan simulasi ketahanan jaringan (Network Robustness) pada jaringan jalan Palabuhanratu, penelitian ini memodelkan keruntuhan sistemik aksesibilitas di bawah skenario genangan Tsunami dengan menerapkan ambang batas kegagalan biner pada kedalaman aliran* h_{max} *> 0.3m. Analisis kuantitatif mengidentifikasi "Jalan Lintas Jabar Selatan" sebagai tulang punggung logistik kritis dengan skor vitalitas tertinggi sebesar 0,19, yang merupakan nilai outlier dominan* *dibandingkan koridor arteri lainnya dalam distribusi jaringan secara bersamaan, simulasi bahaya menunjukkan terbentuknya klaster isolasi taktis di Citarik dan Palabuhanratu, di mana 22,45% titik (node) jaringan mengalami pemutusan akses total (cut-off). Mengingat kedalaman banjir di sektor muara mencapai >7 meter yang melampaui batas kemampuan operasional kendaraan darat, temuan ini menegaskan urgensi strategis bagi penyusunan rencana kontinjensi gabungan yang mengintegrasikan kapabilitas jembatan udara (air-bridge) dan akses maritim guna menjamin keberlanjutan logistik pertahanan nasional selama masa kontinjensi krisis.*

Kata Kunci*: Pertahanan Nirmiliter, Logistik Bencana, Objek Vital Nasional, Betweenness Centrality, OMSP.*

Introduction

The potential for a Megathrust earthquake and subsequent tsunami along the subduction zone of Southern Java constitutes a significant non-military threat to Indonesia's national security. Within the framework of the Total People's Defense and Security System (Sishankamrata), large-scale natural disasters are recognized as events capable of destabilizing regional governance and social order (Mone Methils Carlos et al., 2025; Muslim & Taufik, 2025). Accordingly, Law No. 34 of 2004 on the Indonesian National Armed Forces (TNI) explicitly mandates Military Operations Other Than War (MOOTW/OMSP) for disaster relief (Adilang et al., 2022; Chaisorn, 2022).

This mandate underscores the critical reliance of defense components on civilian infrastructure, requiring a functional bridge where logistics resilience enables effective Civil-Military Cooperation (CIMIC) during catastrophic disruptions. The success of such joint operations heavily relies on the resilience of critical infrastructure, particularly the road network, which serves as the essential transportation infrastructure for troop mobility and logistics distribution (Kartikasari et al., 2021).

In the context of Civil-Military Cooperation (CIMIC), the integrity of the supply chain is paramount. The Center for Excellence in Disaster Management and Humanitarian Assistance (2025) emphasizes that effective coordination between civil and military entities is vital to prevent natural hazards from escalating into complex humanitarian emergencies (CFE-DM, 2025). Therefore, road segments that facilitate the movement of strategic assets and relief supplies must be identified and protected as National Vital Objects (Objek Vital Nasional), defined here as critical assets whose functional integrity is vital for maintaining national security and ensuring the continuity of life-saving operations (Namudat et al., 2018).

However, transport networks in coastal areas are inherently vulnerable to physical disruption caused by tsunami inundation, which leads to the formation of topological bottlenecks and the potential isolation of strategic sectors Palabuhanratu is selected as the focal point of this study due to three strategic urgencies: (1) its location facing a significant seismic gap in the southern Java subduction zone, (2) its high-risk classification in the National Disaster Risk Index, and (3) its high topographical vulnerability characterized by river estuaries that create potential topological bottlenecks.

Prior research conducted by Sudibyo et al. (2026) has comprehensively analyzed the spatial equity of evacuation access, focusing on the outbound flow of population movement from danger zones to safety. Other studies, (Hardiyansyah et al.,2016; Judijanto & Kune, (2025); Setya Lestari & Setiawan, (2023) focus primarily on civilian safety metrics and evacuation modeling. However, as highlighted by Zaitun & Karim (2024) in their systematic review of humanitarian logistics, disaster research predominantly emphasizes relief stockpiling and procurement rather than the spatial vulnerability of last-mile delivery routes in post-disaster scenarios (Decker, 2014).

Consequently, there remains a critical gap in the literature regarding the inbound flow perspective. In this study, this perspective is operationally defined as the functional resilience of land-based supply routes required by defense and rescue units to penetrate affected areas, project MOOTW assets, and provide life-saving aid. The identification of isolated territories that become inaccessible to standard military land vehicles remains a subject that is largely unquantified in current spatial planning.

To address this gap, a quantitative spatial approach based on Graph Theory was employed. Unlike traditional risk assessments that rely on qualitative exposure descriptions or static hazard maps, this methodology utilizes Betweenness Centrality and Network Robustness algorithms to mathematically identify critical road segments and simulate systemic network breakdown scenarios (Zaitun & Karim, 2024). This approach provides a rigorous framework to detect strategic logistics corridors and delineate isolated pockets that necessitate specific Military Operations Other Than War (MOOTW).

The primary objectives of this research are to identify priority road segments qualifying as National Vital Objects (Obvitnas) based on their network criticality and to map tactical isolation clusters requiring alternative access strategies, such as air-bridge or amphibious operations.

Research Methods

A quantitative spatial analysis approach based on Graph Theory was employed to evaluate the resilience of defense logistics networks. This methodology is structured into three sequential phases to ensure scientific transparency and reproducibility: first is data acquisition and the construction of a digital twin network; second is network criticality analysis using Betweenness Centrality algorithms to rank strategic value; and last is network robustness simulation under hazard-driven tsunami scenarios. This systematic framework ensures the reproducibility of findings regarding the identification of National Vital Objects and isolated territories.

Study Area and Data Acquisition

The research focuses on the coastal district of Palabuhanratu, Sukabumi Regency (6°58' 40.8" - 7°01' 01.2" and 106°32' 16.8" - 106 ° 34' 40.8" E). The spatial boundary encompasses administrative units directly exposed to the Indian Ocean, characterized by complex topography modeled using the 8-meter resolution National Elevation Model (DEMNAS), which complicates logistics distribution during emergencies.

Primary spatial data were integrated from multiple sources to construct a high-fidelity geospatial model. The road network data, representing the logistics infrastructure, were acquired from OpenStreetMap (OSM) and processed using the OSMnx library. To ensure network consistency, the configuration applied topological simplification by consolidating degree-2 nodes and removing self-loops, while acknowledging that OSM accuracy depends on metadata completeness.

The road logistics infrastructure network was modeled as a graph $G = (V, E)$, where V represents intersections (nodes) and E represents road segments (edges) assigned with travel-time impedance weights. To simulate the hazard impact, tsunami inundation depth (h_{max}) data were utilized, derived from hydrological modeling scenarios using COMCOT (Cornell Multi-grid Coupled Tsunami model), consistent with previous studies on coastal vulnerability, specifically those by Indira & Manessa (2023) and Sudibyo et al. (2026).

Administrative boundaries for village-level analysis were obtained from the GADM database (GADM, 2025), while the locations of potential National Vital Objects (Obvitnas) were filtered from the West Java and Banten Provincial inventory. The operational filtering criterion for Obvitnas in this context is based on spatial intersection with the hazard zone and functional classification as a primary arterial corridor that serves as a singular connectivity node for regional logistics.

Network Criticality Analysis

To identify road segments that function as the 'backbone' of defense logistics, this study applies the ***Betweenness Centrality (C_B)*** algorithm. This specific metric is preferred over other centrality measures because it evaluates the proportion of network-wide shortest paths that traverse a particular edge, making it highly effective for pinpointing structural bottlenecks or "choke points". In the context of transportation modeling, this metric quantifies the influence of a road segment on the flow of information or goods within the network. The centrality score for an edge $\boldsymbol{e}$ is calculated as the sum of the fraction of all-pairs shortest paths that pass-through ***e:***

$$\boldsymbol{C_B(e) = \sum_{s \neq t \in V} \frac{\sigma_{st}(e)}{\sigma_{st}}}$$

Where $\boldsymbol{\sigma_{st}}$ is the total number of shortest paths between nodes $\boldsymbol{s}$ and $\boldsymbol{t}$, and $\boldsymbol{\sigma_{st}(e)}$ is the number of those paths passing through edge ***e***. Edges with high **C_B** values represent strategic corridors essential for inbound logistics flow. This mathematical criticality provides the empirical bridging logic to defense policy: under the Sishankamrata doctrine, an infrastructure asset whose failure triggers a disproportionate systemic collapse of regional connectivity must be legally secured. Consequently, these high-scoring segments are classified as potential National Vital Objects due to their systemic importance in maintaining the supply chain during disaster relief operations.

Network Robustness and Isolation

The reliability of the logistics network is evaluated through a deterministic failure simulation. A deterministic approach, rather than a probabilistic one, is deliberately employed as a "stress-test" to assess network sensitivity against the worst-case scenario of catastrophic infrastructure collapse. To simulate network disruption, a binary failure threshold of flow depth (**h_{max} > 0.3m**) is applied. While 0.3 meters may intuitively appear shallow, it represents a critical hydrodynamic tipping point in tsunami risk management. According to the UNESCO/IOC Pacific Tsunami Warning System guidelines (IOC Technical Series 105), an amplitude of 0.3m is the exact threshold that triggers an official "Tsunami Threat Message" due to its destructive kinetic energy. Furthermore, human stability experiments in floodwaters (Arrighi et al., 2017) demonstrate that individuals can lose stability at critical mobility parameters (θ_{Pcr}) as low as 0.3 under sub-critical flow conditions. This is further compounded by findings from transportation vulnerability studies (Kramer et al., 2016) indicating that standard vehicles lose frictional traction or become buoyant at water depths exceeding 0.3 meters. When combined with high-velocity flows and the risk of tsunami-borne debris impact, this depth renders road segments tactically compromised and impassable for logistics convoys (Sorrentino & Giresini, 2024). The disruption is executed through a scenario-based topological modification of the road graph. Rather than a static removal of all nodes within the hazard zone, this scenario-based modeling approach mathematically deletes all road edges that exceed the >0.3m hydrodynamic threshold. This includes critical arterial segments and bridge infrastructure, such as the Cimandiri and Citarik bridges—to simulate tactical route paralysis under catastrophic tsunami inundation. This process generates a disrupted network $\boldsymbol{G'}$, mathematically forcing the routing algorithm to either recalculate paths via remaining corridors or identify nodes that have lost all connectivity. A Connected Components analysis is subsequently performed on $\boldsymbol{G'}$ to identify isolated sub-networks. Nodes that remain physically intact but lose connectivity to the main logistics entry points (supply bases) are classified as "Isolated Pockets." This process quantifies the tactical isolation of specific administrative units (villages), providing a measurable indicator for the necessity of Military Operations Other Than War (MOOTW). The results are cross-validated using spatial descriptive statistics to determine the percentage of network failure and the population distribution within isolated clusters. In this study, an isolated cluster is operationally defined as a set of graph nodes that remain physically outside the inundation zone but lose all functional connectivity to the primary logistics entry points, resulting in an infinite travel time ($T_D = \infty$). To measure the magnitude of this failure, the Regional Reachability Ratio ***(RR)*** is employed, which is calculated as follows:

$$\boldsymbol{RR} = \frac{\sum_{i \in N} (\boldsymbol{P_i} \cdot \boldsymbol{S_i})}{\sum_{i \in N} \boldsymbol{P_i}} \times \mathbf{100\%}$$

Where $\boldsymbol{P_i}$ is the population at node $\boldsymbol{i}$, and $\boldsymbol{S_i}$ is a binary safety classification (1 if the total evacuation time $T_{total}(i) \leq 22\,minutes$, and 0 otherwise) This metric allows for the quantification of "node death rates" and the identification of tactical sectors experiencing total mission failure.

Results and Discussion

Identification of Strategic Logistics Corridors (National Vital Objects)

The application of the ***Betweenness Centrality*** **(C_B)** algorithm to the Palabuhanratu road network reveals a distinct hierarchy in the transportation infrastructure's strategic value.

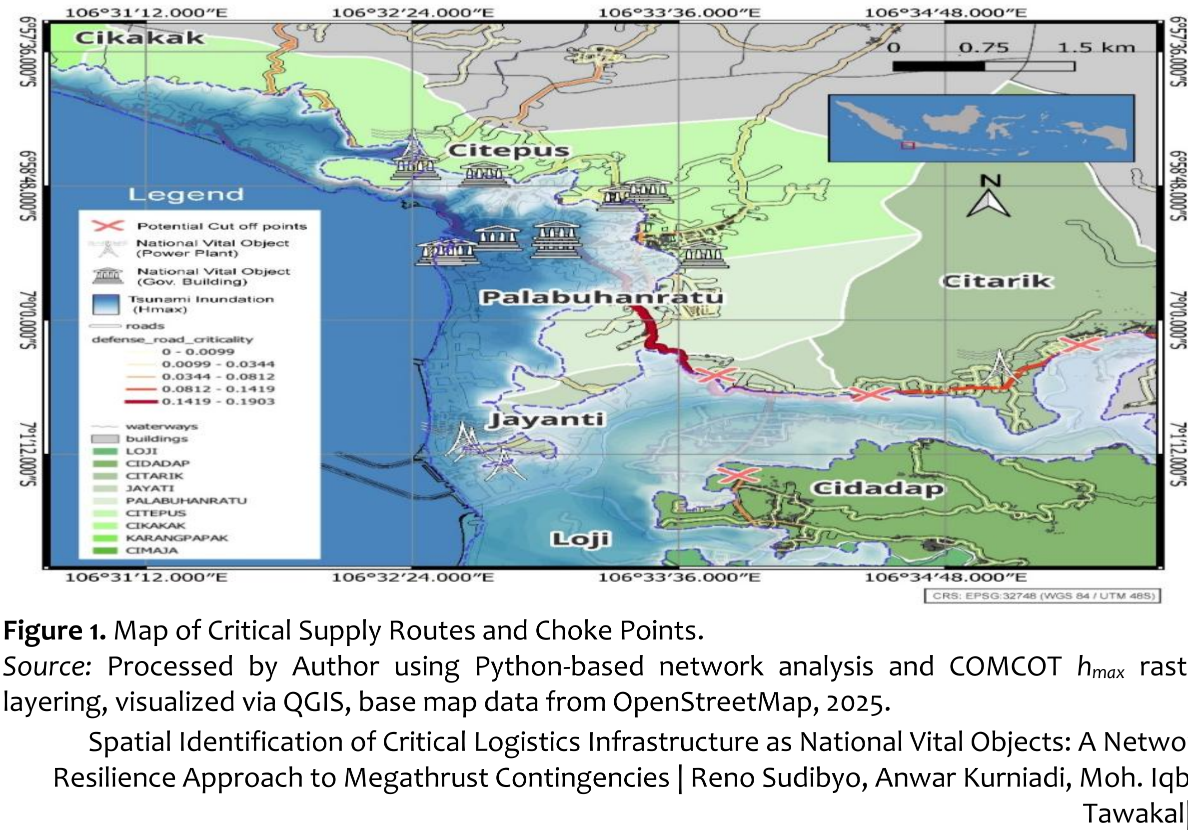

Figure 1. Map of Critical Supply Routes and Choke Points.
Source: Processed by Author using Python-based network analysis and COMCOT h_{max} raster layering, visualized via QGIS, base map data from OpenStreetMap, 2025.

As presented in Table 1 and visualized in Figure 1, the analysis identifies "Jalan Lintas Jabar Selatan" (Southern Java Trans-Regional Road) as the logistic backbone of the region, exhibiting the highest normalized centrality score of 0.1903. To provide interpretative context, this value represents a dominant outlier in the network's distribution, being significantly higher than secondary corridors such as Jl. Raya Cisolok (0.1503) and Jalan Siliwangi (0.1398). This confirms that nearly 20% of all shortest paths in the regional network depend on this singular segment, marking it as a critical "bridge" for logistics flow (Zaitun & Karim, 2024). Furthermore, the identification of such arterial roads is consistent with transport modeling concepts which emphasize the role of primary corridors in sustaining regional connectivity (Tamin, 2000).

Table 1. Top Critical Roads

Road Name	***Max Centrality***	***Avg Centrality***	***Total Length (km)***
Jalan Lintas Jabar Selatan	*0.1903*	*0.1681*	*5.94*
Jl. Raya Cisolok	*0.1503*	*0.1488*	*2.22*
Jalan Siliwangi	*0.1399*	*0.1398*	*0.82*

Source: Network criticality analysis processed from OpenStreetMap (OSM) data, 2025.

This backbone serves as the logistical “Center of Gravity" (CoG) for defense operations operationally defined in this study as the critical set of nodes whose functional failure triggers a total mission failure for 73% of the operational territory (19 out of 26 villages). Unlike dense urban networks which possess high redundancy, the Palabuhanratu network topology is characterized by a lack of alternative routes, rendering the CoGhighly vulnerable. The failure of this specific segment constitutes a systemic failure of the inbound logistics flow. Consequently, this corridor meets the data-driven criteria for classification as a National Vital Object (Obvitnas). In this study, an infrastructure asset is prioritized as Obvitnas if its structural removal causes a systemic reachability (RR) drop exceeding 10%, as evidenced by the 14.72% collapse in Pelabuhanratu's connectivity. This classification necessitates prioritized security measures and structural reinforcement by military engineering units (Zeni TNI) to ensure the continuity of government functions during crises, as mandated for critical infrastructure protection (Kartikasari et al., 2021)

It is critical to address the capability of military transport assets against the identified hazard. Although standard tactical trucks possess deep-wading capabilities, the hydrological analysis reveals that the identified choke point at the Citarik estuary experiences extreme inundation levels. Based on the COMCOT numerical model, flow depths in this specific arterial sector exceed 7.0 meters. While numerical modeling carries inherent uncertainties regarding bathymetric resolution, the 7.0 m projection provides a robust safety margin for defense planning. This depth far surpasses the 1.5m deep-wading capability of standard military 6x6 tactical trucks, confirming that the severance of the logistics backbone is absolute; no land-based vehicle, regardless of its off-road specification, can traverse the inundated estuary, thus validating the strategic necessity for the air-bridge or amphibious MOOTW approach proposed in this study.

Tactical Isolation and Network Robustness

The network robustness simulation, which models the deterministic failure of infrastructure within the inundation zone, reveals significant vulnerabilities in regional accessibility. As detailed in Table 2, the tsunami scenario results in the functional paralysis of 22.45% of the total network nodes. In this context, functional paralysis is operationally defined as the loss of systemic utility of the nodes for logistics flow, quantified by the percentage of the network achieving a Reachability Ratio (RR) of zero.

While these nodes remain physically intact (outside the inundation zone), they become tactically isolated a condition where all functional path connectivity to the primary logistics entry points is severed, resulting in an infinite travel time ($T_D = \infty$) due to the severance of access routes. This phenomenon aligns with the "island effect" described in transportation vulnerability studies, where disaster impacts partition a connected graph into disjointed sub-networks (Simanjuntak et al., 2024).

Table 2. Statistics of Isolated Villages

Village	Sub District	Isolated Nodes	Status
Citarik	Palabuhanratu	132	Major Isolation (Air-Ops Required)
Palabuhanratu	Palabuhanratu	112	Major Isolation (Amphibious Required)

Cidadap	Simpenan	87	Moderate Isolation
Citepus	Palabuhanratu	16	Minor Isolation

Source: Spatial robustness simulation results based on GADM administrative boundaries and tsunami inundation scenarios, 2025.

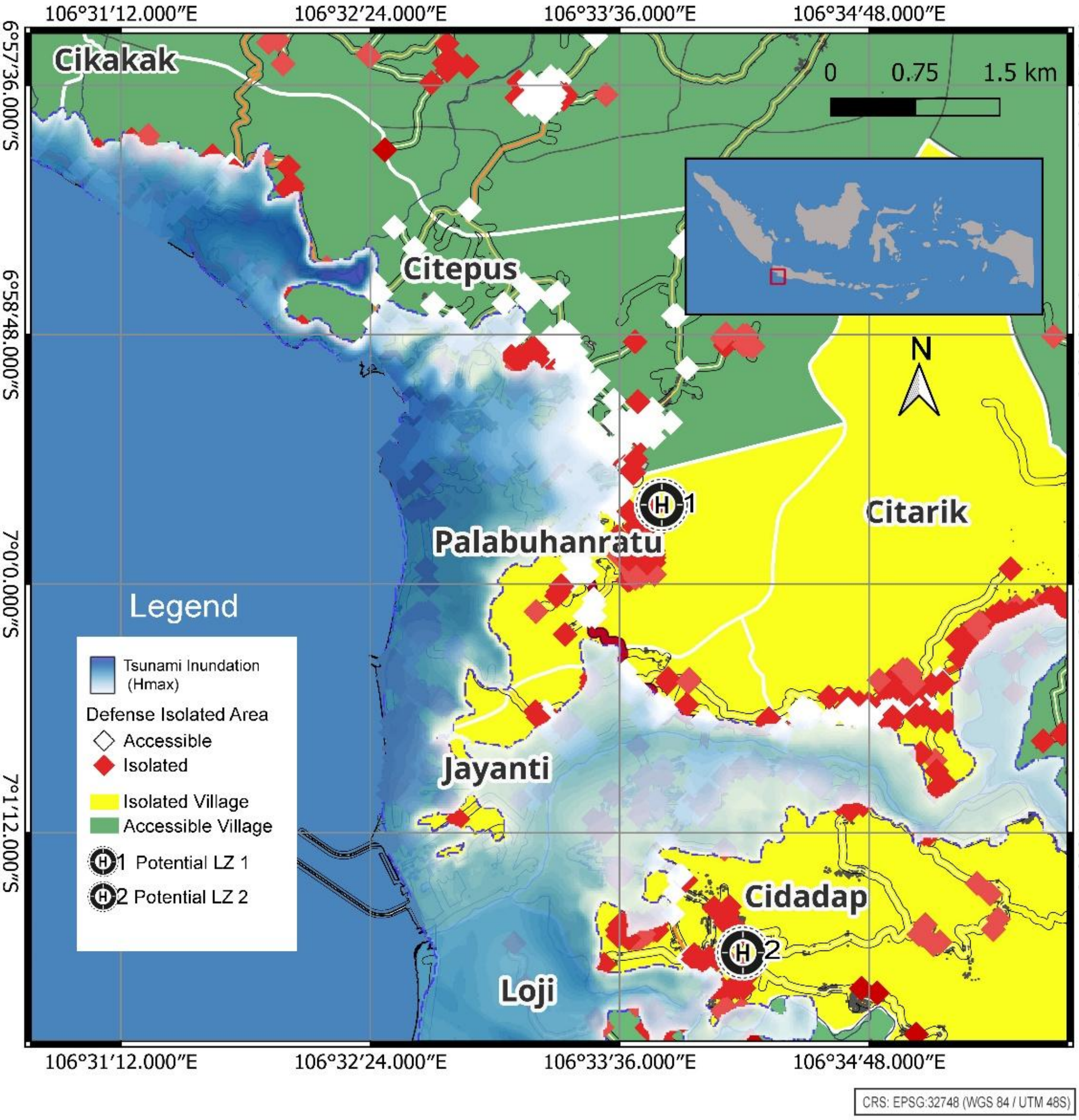

Figure 2. Tactical Map of Isolated Pockets and Operation.
Source: Processed by Author using Python-based robustness simulation and COMCOT h_{max} raster layering, visualized via QGIS, administrative boundaries from GADM, 2025.

Spatial clustering analysis Figure 2 localizes this isolation effect into distinct tactical sectors. The most severe isolation is observed in Citarik Village (132 isolated nodes) and Palabuhanratu (112 isolated nodes). These "Isolated Pockets" represent a critical gap in traditional evacuation planning. While previous studies have extensively modeled the **outbound** evacuation of populations (Setya Lestari & Setiawan, 2023; Sudibyo et al., 2026), they often overlook the inbound accessibility required for relief supplies. From a risk management perspective, these clusters represent high-risk zones where the probability of a humanitarian crisis escalates rapidly due to the inability of standard military land vehicles (e.g., trucks) to penetrate the area. The concentration of isolation in these specific administrative units dictates that the allocation of defense resources must shift from a generalized distribution model to a targeted, sector-specific operation (Sidik et al., 2024).

Operational Implications for Defense Logistics (OMSP)

The identified spatial disconnectivity necessitates the activation of Military Operations Other Than War (MOOTW/OMSP) as mandated by Law No. 34 of 2004 (Adilang et al., 2022). The operational implications of the findings suggest that reliance on land-based lines of communication (LOC) is untenable for the first response phase in Citarik and Palabuhanratu. Instead, the contingency plan must integrate Civil-Military Cooperation (CIMIC) frameworks to establish alternative supply chains (Azizah & Wibowo, 2025; Civil-Military Cooperation Centre of Excellence, 2025)

Based on the terrain analysis and isolation mapping, this study proposes a dual-modal logistics strategy driven by explicit spatial decision rules:

1. Air-Bridge Operation: This mode is indicated for inland isolated clusters (e.g., Citarik, 132 isolated nodes) where road networks are severed by >7m estuary inundation and direct maritime access is geographically impossible. The isolation of the inland Citarik sector requires the deployment of rotary-wing assets (helicopters). The identification of "Emergency Landing Zones" (LZ) in non-inundated areas adjacent to the isolated clusters ensures the continuity of "last-mile" distribution. This approach is essential when terrestrial infrastructure is compromised (Abou Kasm et al., 2025; Chaisorn, 2022; Hidayat et al., 2017; Thomas, 2022)
2. Amphibious Logistics Operation: This mode is indicated for coastal isolated pockets (e.g., Palabuhanratu, 112 isolated nodes) where inland road access is severed, but direct geographical adjacency to the ocean remains viable for

maritime insertion. For the coastal isolated pockets in Palabuhanratu, where road access is severed by estuary inundation, the deployment of Landing Craft Utility (LCU) vessels is recommended. This aligns with the maritime defense strategy of utilizing coastal access for humanitarian relief to support regional resilience (Prastyo, 2024).

These represent data-driven adaptations of defense logistics to megathrust realities.

Conclusions, Recommendations, and Limitations

This study suggests that defense logistics in Palabuhanratu face a vulnerability under megathrust scenarios, primarily due to the strategic fragility of "Jalan Lintas Jabar Selatan". The lack of network redundancy leads to a systemic choke point at the estuary, causing functional paralysis for 22.45% of the network nodes, particularly in Citarik and Palabuhanratu. This quantitative finding shifts the analytical focus from civilian evacuation to the absolute necessity of non-land-based logistics, such as air and amphibious operations, to bridge the distribution gap during the emergency response phase.

To mitigate these risks, it is recommended that the "Jalan Lintas Jabar Selatan" corridor be formally designated as a National Vital Object (Obvitnas) to prioritize its protection and structural reinforcement by military engineering units (Zeni TNI). On top of that, national defense doctrine must adapt by updating local contingency plans (Renkon) to include specific scenarios for isolated clusters and conducting joint exercises that simulate air-bridge and amphibious landings. Establishing a permanent logistics coordination hub outside the hazard zone under a Civil-Military Cooperation (CIMIC) framework is essential to streamline aid flow from the strategic backbone to the tactical edge.

While this research provides a structural quantitative foundation for defense planning by identifying static topological vulnerabilities, it is inherently limited by a static graph topology which does not account for dynamic traffic behavior or granular structural data. Directly addressing these limitations, future studies should implement multi-class agent-based models to differentiate vehicle capabilities (e.g., military 6x6 trucks vs. civilian vehicles) and integrate multi-modal transportation graphs including maritime and riverine routes to transform technical travel times into granular operational estimates. Such advancements will allow for a more detailed assessment of road capacity saturation and the dynamic interaction between outbound evacuee flows and inbound logistics convoys.

References

Abou Kasm, O., Raymer, M., & Diabat, A. (2025). A drone-assisted last-mile delivery framework for shipment prioritization in post-disaster and high demand periods. *Applied Mathematical Modelling*, *146*. https://doi.org/10.1016/j.apm.2025.116175

Adilang, D. C., Tungka, A. E., & Warouw, F. (2022). Pemetaan Jalur Evakuasi Tsunami dengan Metode Network Analyst Berbasis SIG di Kota Manado. *Jurnal Perencanaan Wilayah Dan Kota*, 9(1), 52–1.

Arrighi, C., Oumeraci, H., & Castelli, F. (2017). Hydrodynamics of pedestrians' instability in floodwaters. Hydrology and Earth System Sciences, 21(1), 515-531. https://doi.org/10.5194/hess-21-515-2017

Azizah, N. A., & Wibowo, A. A. (2025). *Pemodelan Jalur Distribusi Logistik dalam Situasi Krisis Gempabumi Kota Palu*. Universitas Muhammadiyah Surakarta.

CFE-DM. (2025). *Indonesia Disaster Management Reference Handbook Disaster Management Reference Handbook Series*. Center for Excellence in Disaster. https://www.cfe-dmha.org

Chaisorn, P. (2022). Civil-Military Cooperation in Humanitarian Assistance and Disaster Relief: The Legal Frameworks. *Brawijaya Law Journal*, 9(1), 16–32. https://doi.org/10.21776/ub.blj.2022.009.01.02

Civil-Military Cooperation Centre of Excellence. (2025). *The Evolution of Civil-military Cooperation*.

GADM. (2025). *Global Administrative Areas*.

Hardiyansyah, Priyanto, S., Muthohar, I., & Budi Suparma, L. (2016). Konsep Pemodelan Transportasi untuk evakuasi Bencana. *Jurnal Transportasi*, *16*(3), 231–240.

Hidayat, R. D. R., Iqbal Firdaus, M., & Lesmini, L. (2017). Pengelolaan Gudang Logistik Kemanusiaan BNPB. *Jurnal Manajemen Industri Dan Logistik*, *1*(2), 1–12.

Judijanto, L., & Kune, D. (2025). Resiliensi Rantai Pasok dalam Literatur Bisnis: Studi Bibliometrik dan Visualisasi Jaringan Article Info ABSTRAK. In *Jurnal Bisnis dan Manajemen West Science* (Vol. 4, Issue 01).

Kartikasari, W., Setiawan, D., & Fauziah, E. (2021). Efektifitas Transportasi dan Lokasi Terhadap Distribusi Logistik di Wilayah Komando Armada I TNI-AL. *Rekayasa*, *14*(2), 183–190. https://doi.org/10.21107/rekayasa.v14i2.10968

Kramer, M., Terheiden, K., & Wieprecht, S. (2016). Safety criteria for the trafficability of inundated roads in urban floodings. International Journal of Disaster Risk Reduction, 17, 77-84.

https://doi.org/10.1016/j.ijdrr.2016.04.003

Mone Methils Carlos, D., Jupriyanto, & Henu Basworo, G. (2025). Operasi dan Pemeliharaan Sungai sebagai Bagian dari Strategi Pertahanan Negara terhadap Ancaman Nirmiliter (Studi Kasus: DAS Progo). *Jurnal Serambi Engginering*, *X* (4), 15517–15523.

Muslim, K., & Taufik, A. (2025). Model Manajemen Resiko dalam Administrasi Pertahanan: Kajian Literatur Sistematis Terhadap Ancaman Hibrida Dan Non-Militer. *Jurnal Dwija Kusuma*, *13*(2), 92–103. https://doi.org/10.63824/administrasipertahanan

Namudat, H., Karlina, N., & Rusli, B. (2018). Analisis Kebijakan Pengaman Obyek Vital Nasional di PT Freeport Indonesia. *Responsive*, *1*(2), 39–44.

Noviantoro, K. M., Widjaja, H. R., & Ridwan, M. (2022). Penataan Ruang Wilayah Pesisir sebagai Upaya Mitigasi Bencana Tsunami di Pantai Watu Pecak, Kabupaten Lumajang. *Jurnal Wilayah Dan Lingkungan*, *10*(3), 236–245. https://doi.org/10.14710/jwl.10.3.236-245

Prastyo, Y. (2024). Kebijakan Pemerintah Dalam Mewujudkan Strategi Coastal Defense dengan pendekatan Anti-Access Area Denial (A2/AD) Sebagai Pertahanan Di Kawasan Indonesia. *Journal of Education, Humaniora and Social Sciences (JEHSS)*, *7*(2), 835–847. https://doi.org/10.34007/jehss.v7i2.2385

Setya Lestari, A., & Setiawan, C. (2023). Mitigasi Bencana Tsunami Pantai Pangandaran, Jawa Barat. *Jurnal Pendidikan Dan Ilmu Geografi*, *8*, 55–2. http://ejournal.unikama.ac.id/index.php/JPIG/

Sidik, R. F., Suharnoto, Y., & Sutoyo. (2024). Analisis Tingkat Kerawanan Dan Upaya Mitigasi Bencana Tsunami Studi Kasus: Pesisir Kabupaten Tasikmalaya. *Jurnal Teknik Sipil Dan Lingkungan*, 9(2), 179–188. https://doi.org/10.29244/jsil.9.2.179-188

Simanjuntak, S. D. J., Siahaan, T., Deksino, G. R., & Ophelia, N. (2024). The Role of Defense Science Philosophy in Determining Strategies to Maintain the Sovereignty and Integrity of The Unitary State of The Republic Indonesia in Industrial Revolution 4.0. In *International Journal Of Humanities Education And Social Sciences* (Vol. 3, Issue 5). https://ijhess.com/index.php/ijhess/

Sudibyo, R., Kurniadi, A., Subiyanto, A., & Gilang Ramadhan, F. (2026). Network-based equity evaluation of tsunami evacuation access for a megathrust scenario in Palabuhanratu. *Jurnal Meteorologi Dan Geofisika*, 26(2), 109–122. https://doi.org/https://doi.org/10.31172/jmg.v26i2.1196

Tamin, O. Z. (2000). *Perencanaan dan pemodelan transportasi*. Penerbit ITB.

Thomas, A. (2022). *Humanitarian Logistics: enabling disaster esponse*. Fritz Institute.

UNESCO/IOC. (2014). User's Guide for the Pacific Tsunami Warning Center Enhanced Products for the Pacific Tsunami Warning System. IOC Technical Series, 105. Paris: UNESCO.

Zaitun, & Karim, V. (2024). Systematic Review Logistik Kemanusiaan di Indonesia: Tinjauan dan Usulan untuk Penelitian Masa Depan. *Logistik*, 209–222. https://doi.org/https://doi.org/10.21009/logistik.v17i02.49675