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Geospatial decision support system for smart Indonesian military logistics depot planning in Papua-Indonesia conflict zones

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ABSTRACT
Background: Papua, Indonesia, is a strategic region characterized by complex geography, limited infrastructure, and security dynamics that affect the effectiveness of defense logistics distribution. This study aims to develop a Geospatial Decision Support System to determine strategic locations for Smart *TNI* Logistics Depots in Papua conflict zones through geoinformatics-based spatial analysis. **Methods:** A mixed-methods approach was employed, integrating qualitative phase using NVivo, quantitative phase using SEM-PLS, and geospatial analysis using Geographic Information Systems. **Results:** Qualitative findings indicate that limited regional accessibility and dependence on external logistics supply chains are the primary constraints affecting defense logistics distribution in Papua. SEM-PLS analysis demonstrates that defense logistics positively and significantly affects the effectiveness of the Geospatial Decision Support System ($\beta = 0.690$; $p < 0.05$). GIS-based spatial analysis identifies strategic logistics depot locations near conflict zones and transportation networks to improve logistics distribution efficiency and operational response. **Conclusion:** Integrating geoinformatics technology with defense logistics through a Geospatial Decision Support System (GDCS) can enhance the effectiveness of logistics depot planning and strengthen operational readiness in Papua conflict areas. **Novelty/Originality of this article:** This study lies in the development of a decision-support model that integrates NVivo thematic analysis, SEM-PLS validation, and GIS-based spatial modeling within a single analytical framework for planning *TNI* defense logistics depots in regions facing complex geographical conditions and ongoing security challenges.

KEYWORDS: conflict zones; Indonesia defense; military logistics; Papua region; spatial analysis.

1. Introduction

The Papua region of Indonesia is one of the country's strategic areas characterized by high geographical, social, and security complexity. The geographical conditions of Papua, which are dominated by mountains, tropical forests, and limited land, sea, and air transportation infrastructure, make logistics mobilization and resource distribution a major challenge, particularly in supporting security stability and public services in areas where conflicts still occur (Antai et al., 2024). In this context, the defense logistics system becomes an important component in supporting the operational readiness of the Indonesian National Armed Forces & the government to maintain stability in the Papua region. However,

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logistics management in this area still faces several obstacles, such as limited regional accessibility, long distances between locations, dependence on defense logistics supplies from outside Papua, particularly from Java Island, and the underutilization of geospatial technology in planning defense logistics distribution (Bury, 2021).

At the same time, developments in global geopolitics indicate that modern conflict dynamics are increasingly influenced by a country's ability to manage logistics systems, information systems, and technologies based on spatial data (Halizahari et al., 2022). Recent developments in defense operations demonstrate that logistics resilience, spatial intelligence, and geospatially informed decision-making are increasingly important in supporting operational effectiveness. In geographically complex and conflict-prone regions such as Papua, logistics performance is highly dependent on accessibility, transportation connectivity, and operational mobility. Therefore, integrating geospatial analysis into defense logistics planning has become essential for improving logistics efficiency and supporting regional security stability. The conflict has triggered a series of retaliatory attacks using missiles and drones targeting military bases, energy routes in the Strait of Hormuz in the Red Sea region near Iran, and strategic infrastructure across several Middle Eastern countries (Sun et al., 2022). These developments have affected global trade and regional security stability, including Indonesia. Furthermore, the escalation of the conflict has disrupted global energy trade routes and international logistics chains, leading to an increase in global oil prices. This situation demonstrates the critical role of strategic logistics systems in addressing increasingly complex global security dynamics (Sayadyan & Gevorgyan, 2020).

These developments provide important lessons for Indonesia, particularly in addressing security challenges in Papua, where conflict still persists. In the context of modern security, a country's ability to manage strategic logistics systems and make decisions based on geospatial information has become a key factor in maintaining regional stability. In Indonesia, especially in Papua, where geographical conditions are highly complex and security dynamics are fluctuating, conventional approaches to defense logistics management are no longer adequate or effective. Therefore, a geospatial technology-based approach is required to integrate various spatial data, including regional topography, transportation networks, the distribution of conflict areas, and strategic locations, to support more effective planning and strengthening of defense logistics systems (Khadim et al., 2021). Remote sensing data also provide important support for identifying terrain characteristics, land cover conditions, environmental constraints, and transportation accessibility in remote operational areas. The integration of remote sensing information with GIS-based spatial analysis enhances the accuracy of logistics planning and strategic decision-making in conflict-prone regions such as Papua.

The development of geoinformatics technologies, remote sensing, particularly Geographic Information Systems (GIS), and spatial data-based decision support systems, offers significant opportunities to support strategic decision-making in defense logistics management (Marano et al., 2019). Geospatial Decision Support System, the planning of defense logistics depot locations can be conducted more systematically using comprehensive spatial analysis (Manna et al., 2024). This approach enables the identification of ideal and optimal logistics depot locations based on regional accessibility, proximity to operational areas, the influence of global geopolitical dynamics such as developments in the Middle East, and the efficiency of logistics distribution networks (Rosalina & Saputro, 2022).

Based on these conditions, research on a Geospatial Decision Support System for Smart Indonesian national armed forces/*Tentara Nasional Indonesia* (*TNI)* logistics Depots in Papua conflict zones becomes highly relevant and necessary. This study is important not only in improving the effectiveness of the defense logistics system in Papua but also in responding to global geopolitical dynamics, including the impact of conflicts in the Middle East, which demonstrate that advanced logistics systems supported by geospatial technology and information play an important role in maintaining national security stability and safeguarding public interests (Skopeliti et al., 2025). By utilizing a geoinformatics approach based on GIS, this research is expected to produce a defense logistics depot planning model that is more adaptive to the geographical conditions of Papua and capable of supporting security stability and strategic decision-making more effectively (Ti & Kinsey, 2023).

Although a number of studies have examined defense logistics management and the use of geospatial technologies in security systems, most existing studies focus primarily on policy aspects, conventional logistics management, or the partial use of geospatial technologies (Suroso, 2022). Research that specifically integrates geospatial analysis based on Geographic Information Systems, remote sensing, and geospatial decision support systems to determine strategic locations for defense logistics depots in conflict areas such as Papua remains relatively limited. In addition, studies that link geoinformatics-based defense logistics planning with global geopolitical dynamics, such as the impact of Middle Eastern conflicts on global logistics chains and security stability, are still scarce. Therefore, research is needed to develop a comprehensive spatial analysis-based decision-making model for defense logistics planning to support security stability in conflict areas (Woschank et al., 2020).

Based on these conditions, the main problem addressed in this study is how to develop a geospatial-based decision support system capable of determining optimal strategic locations for *TNI* logistics depots in conflict areas of Papua . This problem includes how geoinformatics technologies such as GIS and remote sensing can be used to analyze geographical conditions, transportation networks, the distribution of conflict areas, and regional accessibility factors in order to support defense logistics planning. In addition, this study seeks to examine how a geospatial approach can enhance the effectiveness of defense logistics systems in addressing the geographical challenges of Papua and the increasingly complex dynamics of global security (Acero et al., 2020).

Previous studies have generally examined defense logistics, GIS applications, and geospatial decision-support systems separately. Existing literature primarily focuses on logistics efficiency, transportation accessibility, or spatial analysis independently, while limited studies integrate qualitative, quantitative, and geospatial approaches into a unified defense logistics planning framework for conflict-prone regions. Therefore, this study attempts to bridge this gap by combining SEM-PLS validation, GIS spatial modeling, and qualitative thematic analysis within a Geospatial Decision Support System framework.

This research aims to develop a Geospatial Decision Support System model that can be used to determine strategic locations for *TNI* logistics depots in Papua conflict areas more effectively through spatial analysis. The study also aims to analyze how geoinformatics technologies, particularly GIS and remote sensing, can support defense logistics planning through the integration of spatial data such as regional topography, transportation networks, the distribution of conflict areas, and accessibility factors. In this way, the research is expected to contribute to the development of a defense logistics system that is more adaptive to regional geographical conditions while supporting national security stability (Aylak et al., 2021). The contribution of this study lies in integrating qualitative analysis, SEM-PLS validation, and GIS-based spatial modeling into a unified geospatial decision-support framework for defense logistics depot planning in Papua conflict zones. Although GIS and logistics optimization methods have been widely used individually, their integration within the context of Indonesian defense logistics planning in geographically complex conflict areas remains relatively limited (Zhiwen et al., 2020).

2. Methods

This study employs mixed methods approach with a descriptive research design that integrates qualitative, quantitative, and geospatial analyses based on geoinformatics to examine the development of Geospatial Decision Support System (GDSS) for determining strategic locations of Smart *TNI* Logistics Depots in conflict areas of Papua (Harefa et al., 2024; Harefa & Supriyadi, 2025). The mixed-methods approach was selected because it allows the integration of conceptual, empirical, and spatial analyses in a comprehensive manner to understand the dynamics of defense logistics management in regions characterized by high geographical and security complexity (Salajegheh et al., 2024). The qualitative phase involved nine purposively selected participants with expertise in defense logistics, military operations, and strategic planning in Papua. Data collection was continued until thematic saturation was achieved, where no substantially new themes or conceptual insights emerged from additional interviews. This approach follows qualitative research principles emphasizing depth of expert perspectives rather than statistical generalization (Al-Eisawi, 2022). Qualitative analysis was carried out using NVivo 12 software to identify key title or themes, relationship patterns, and linkages among variables related to the defense logistics system, the distribution of conflict areas, regional accessibility, and strategic logistics management policies (Dhakal, 2022). The analytical process involved coding, categorization, and mapping the relationships between concepts in order to produce a conceptual model for strengthening geospatial-based defense logistics systems (Kovács & Falagara Sigala, 2021).

The quantitative stage was conducted using Structural Equation Modeling Partial Least Squares PLS.4 to test the relationships among constructs within the research conceptual model(Hair et al., 2020). This method allows simultaneous testing of relationships between variables in the outer model and inner model (Akhter et al., 2024). In the outer model, convergent validity was assessed using loading factor values greater than 0.70 & Average Variance Extracted values greater than or equal to 0.50. Reliability testing was performed using Composite Reliability and Cronbach's Alpha with values greater than 0.70 (Liengaard et al., 2021). Discriminant validity was evaluated through cross loading analysis, the Fornell-Larcker criterion, and HTMT to ensure construct validity. In the structural model, testing was conducted using hypothesis p-value > 0.05, t-statictic, p-value, and f-square. The fit model includes CVPAT and PLS Predict (Hauff et al., 2024). Sample of this study is 150 respondents who were members of the Indonesian National Armed Forces (*TNI*) currently deployed in Papua. The research instrument used a questionnaire based on a Likert scale, which was distributed to respondents digitally using Google Forms. Research Hypothesis is the development of *TNI* defense logistics depots in conflict-prone areas of Papua has a positive and significant influence on decision-making for national defense, supported by valid geospatial data.

The geospatial analysis stage was conducted used Geographic Information Systems (GIS) to identify strategic locations for defense logistics depots in Papua (Manna et al., 2020). Spatial analysis was performed using data on regional topography, transportation networks, the distribution of conflict areas, and regional accessibility factors through spatial analysis, network analysis, and location-allocation modeling techniques. This approach enables the identification of optimal logistics depot locations based on logistics distribution efficiency, proximity to operational areas, and accessibility that can support defense logistics mobility more effectively (Mileti et al., 2022). Spatial analysis was conducted using ArcGIS Pro 3.2 and QGIS 3.34 software platforms. Spatial datasets included digital elevation models, transportation networks, administrative boundaries, and conflict distribution data obtained from publicly available government and geospatial databases. The analysis used the WGS 84 coordinate reference system (EPSG:4326). Location-allocation modeling considered accessibility, proximity to conflict zones, transportation connectivity, and operational mobility efficiency as the main decision criteria.

Data Validity using method triangulation and data source triangulation, involving both primary and secondary data, as well as researcher verification of the collected data. The study was conducted in Papua, Indonesia, focusing on spatial analysis of conflict areas and defense logistics networks supporting *TNI* operational mobility. Data collection and analysis were carried out in several relevant institutions associated with defense logistics policy and spatial data management. The research was conducted between December 2025 and March 2026. Research Ethics: By obtaining prior permission from the Indonesian Defense University, securing consent from participants who serve as defense logistics experts, and ensuring that respondents are first provided with a clear explanation of the study and voluntarily agree to participate. The confidentiality of respondents' identities is fully guaranteed.

3. Results and Discussion

3.1 Research findings based on qualitative data analysis

The qualitative analysis in this study aimed to explore strategic issues related to defense logistics systems in Papua by integrating empirical, doctrinal, and expert-based perspectives. Data collection was conducted through document analysis, literature review, and in-depth interviews with nine participants consisting of *TNI* officers with operational logistics experience, defense academics, and practitioners involved in strategic logistics planning in Indonesia. The interviews focused on identifying challenges in logistics distribution, regional accessibility, operational readiness, conflict dynamics, and the utilization of geospatial technology in defense logistics management. The collected qualitative data were systematically processed using NVivo software through coding, thematic categorization, and conceptual relationship mapping to identify dominant patterns and emerging themes. The analysis revealed several key issues, including limited transportation infrastructure, long distribution routes, dependence on external supply chains, uneven logistics accessibility, and the strategic importance of conflict-zone proximity in logistics planning. In addition, the literature review and analysis of defense logistics doctrines highlighted the significance of supply sustainability, rapid operational mobility, logistics resilience, and integrated command systems in supporting military operations. By combining expert insights, doctrinal frameworks, and empirical literature findings, this qualitative phase provided a comprehensive conceptual foundation for the development of a Geospatial Decision Support System (GDSS) to support strategic planning and spatial decision-making for Smart *TNI* Logistics Depots in Papua conflict zones (Kostiuchenko & Kostiuchenko, 2020).

The results of the qualitative analysis indicate that regional accessibility is a dominant theme in strengthening the defense logistics system in Papua. The coding and categorization processes reveal that Papua's mountainous terrain, dense tropical forests, and limited land, sea, and air connectivity cause logistics distribution to conflict-prone areas to be slow, costly, and unstable. These findings confirm that logistics challenges in Papua are not merely related to the availability of supplies but are also spatial issues that affect distribution reach, mobilization speed, and the continuity of operational support for the Indonesian National Armed Forces (Aćimović et al., 2022).

Document analysis and secondary data indicate that the defense logistics system in Papua still relies heavily on supplies from outside the region, particularly from Java Island, Jayapura, and Manokwari. This pattern creates vulnerabilities in responding to conflict escalation because the distribution routes become long, multi-layered, and prone to disruption. The mapping of conceptual relationships using NVivo shows that this dependence is closely related to the absence of strategically distributed logistics depots near operational areas. Therefore, the need to strengthen locally based logistics depots emerges as an important finding in this study (Cherchata et al., 2022).

The qualitative findings also show that logistics challenges in Papua are not solely technical but also institutional and governance-related. The analysis reveals a strong relationship between inter-unit coordination issues, logistics management policies, and the effectiveness of supply distribution. Through the coding process, a pattern emerges indicating that logistics management still operates partially and is not fully integrated into a rapid, adaptive, and field-oriented decision-making system. Therefore, strengthening defense logistics requires improvements in governance, institutional integration, and synchronization of operational policies (Harefa & Supriyadi, 2025).

The NVivo analysis shows that the use of geospatial technology appears as a central theme in the conceptual model for strengthening defense logistics. Various documents and scientific publications analyzed in this study indicate that remote sensing, Geographic

Information Systems , and spatial data can support the identification of more appropriate logistics depot locations based on topography, accessibility, proximity to conflict zones, and the efficiency of distribution networks. These findings suggest that conventional approaches to depot placement are no longer adequate, making geospatial-based decision support systems necessary to produce more precise and strategic depot planning (Fan et al., 2022).

Fig. 1. Word cloud NVivo 12

The qualitative findings emphasize that strengthening Smart *TNI* Logistics Depots is not only relevant for improving logistics distribution but also has strategic significance in enhancing operational readiness and deterrence in conflict areas. Conceptual mapping shows a relationship between logistics availability, mobilization speed, supply sustainability, and the state's ability to maintain security stability. Therefore, the presence of intelligent, integrated, and strategically located logistics depots is understood as an important instrument for strengthening military response, reducing operational vulnerabilities, and supporting security stability in Papua (Sobb et al., 2020).

The strengthening and development of defense logistics depots in Papua are shaped by four main elements (regional accessibility, the distribution of conflict zones, strategic defense logistics governance, and the integration of geospatial technology). The relationship among these elements shows that the effectiveness of developing defense logistics depots in Papua cannot be determined solely by storage capacity, distribution capability, and the availability of supply chains. It must also be supported by prior spatial analysis, policy synchronization, and an operational orientation focused on effectiveness and efficiency in supporting the primary duties of defense human resources.These findings provide a foundation for the Ministry of Defense of the Republic of Indonesia, the Indonesian National Armed Forces, regional governments, the central government, and other relevant stakeholders in developing defense logistics depots in Papua based on a Geospatial Decision Support System. This system can serve as a guideline for decision-making before determining the locations of Smart *TNI* Logistics Depots in conflict areas of Papua (Antai et al., 2024).

3.2 Quantitative stage: Outer model

The Figure 2 presents the outer loading results from SEM-PLS 4, illustrating the relationship between the (X) Defense Logistics variable and the Geospatial Decision Support System (GDSS) in supporting the development of Smart *TNI* Logistics Depots in conflict areas of Papua. The Defense Logistics variable is represented by five main indicators, including logistics storage and distribution capacity, operational readiness and rapid mobilization capability, logistics management efficiency, the strategic location of defense logistics depots, and the sustainability of resilient supply chains (Harefa, Harahap, Dewi, Nurrobi, & Harsono, 2026). The outer loading values range from 0.745 to 0.926, indicating that all indicators processed using SEM-PLS 4 are statistically valid in representing the defense logistics system. Meanwhile, the (Y) Geospatial Decision Support System variable is measured through indicators related to spatial analysis capability and strategic decision-making based on geospatial data, with outer loading values of 0.938 and 0.817, which demonstrate strong contributions to the regional logistics decision-making approach.

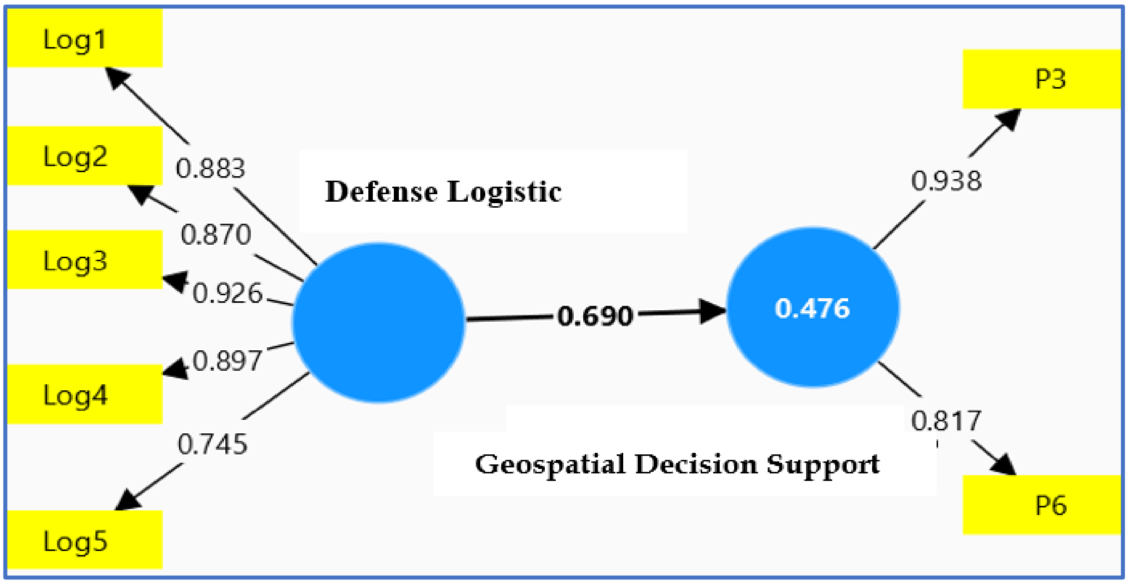

Fig. 2. Outer model

The path coefficient value of 0.690 indicates that strengthening and developing the Defense Logistics depot system can significantly improve the effectiveness of the Geospatial Decision Support System. This means that the stronger the development and reinforcement of the defense logistics system in Papua, the more optimal the use of geospatial decision support in determining the location and management of Smart *TNI* Logistics Depots in conflict areas such as Papua. The model can also serve as a reference for other regions in Indonesia or for countries facing similar geographic and security challenges (Harefa, Harahap, Dewi, Nurrobi, Sutanto, et al., 2026). The R^2 value of 0.476 indicates that approximately 47.6% of the effectiveness of GDSS in this study is influenced by the defense logistics variable. This finding confirms that the integration of logistics systems and geospatial analysis plays an important role in supporting more strategic *TNI* logistics depot planning, adapting to the geographic conditions of Papua, and improving operational readiness in conflict areas (Lagin et al., 2022).

Table 1. AVE value

Variable	Average Variance Extracted
Defense Logistics	0.751
Geospatial Decision support	0.774

Table 1 shows the Average Variance Extracted (AVE) values for the variables in the study. The AVE value for the (X) Defense Logistics variable is 0.751, while the (Y) Geospatial Decision Support System variable has an AVE value of 0.774. Both values are above the recommended threshold of ≥ 0.50. This means that each construct is able to explain more than 50 percent of the variance of its indicators, indicating that the constructs have good convergent validity. These findings are consistent with the results of the previous path diagram analysis, which shows that defense logistics indicators such as distribution capacity, operational readiness, logistics management efficiency, and the strategic location of logistics depots strongly represent the Defense Logistics variable. This variable subsequently has a significant influence on the effectiveness of the Geospatial Decision Support System in determining the locations of Smart *TNI* Logistics Depots in Papua (Dmuchowski, 2021).

Table 2. Outer loading

Indicator	Outer loadings
Log1 <- Defense Logistics	0.883
Log2 <- Defense Logistics	0.870
Log3 <- Defense Logistics	0.926
Log4 <- Defense Logistics	0.897
Log5 <- Defense Logistics	0.745
P3 <- Geospatial Decision Support	0.938
P6 <- Geospatial Decision Support System	0.817

Table 2 shows the results of the outer loading test, which is used to evaluate the strength of the relationship between the indicators and their latent constructs in the SEM-PLS measurement model. The analysis indicates that all indicators of the Defense Logistics variable Log1 (0.883), Log2 (0.870), Log3 (0.926), Log4 (0.897), and Log5 (0.745) have outer loading values above the recommended threshold of 0.70, confirming that each indicator is valid in representing the defense logistics construct. Among these indicators, Log3 (0.926) provides the strongest contribution and relates to the strategic location of logistics depots, followed by Log4 (0.897) and Log1 (0.883), which emphasize the importance of distribution capacity and logistics management efficiency. For the Deterrent Strategy variable, which is supported by the Geospatial Decision Support System, two indicators are used: P3 (0.938) and P6 (0.817). Both values exceed the required threshold, indicating strong validity in measuring the construct. Overall, these results support earlier findings that improvements in the Defense Logistics system play an important role in strengthening the effectiveness of geospatial decision support for determining the locations of Smart *TNI* Logistics Depots in conflict areas of Papua, which in turn contributes to greater operational readiness and supports deterrence efforts in maintaining regional security stability (Bădilă et al., 2024).

Table 3. Reliability test

	Cronbach's alpha	Composite reliability	Composite reliability
Defense Logistics	0.918	0.968	0.937
Geospatial Decision Support System	0.724	0.857	0.872

Table 3 presents the results of the reliability test, which was conducted using Cronbach's Alpha and Composite Reliability to evaluate the internal consistency of the indicators in each construct. The Defense Logistics variable shows a Cronbach's Alpha value of 0.918 and Composite Reliability values of 0.968 and 0.937, indicating a very high level of reliability. Similarly, the Geospatial Decision Support variable records a Cronbach's Alpha value of 0.724 and Composite Reliability values of 0.857 and 0.872, which are also above the commonly accepted threshold of 0.70. These results indicate that the indicators used in both variables are consistent in measuring their respective constructs. In other words, the measurement model demonstrates good internal consistency and reliability, meaning that the variables used in this study are stable and suitable for explaining the relationship between defense logistics and geospatial decision support in the planning of Smart *TNI* Logistics Depots in Papua (Harefa & Harsono, 2025).

Table 4. Monotrait ratio monotrait ratio

	Defense Logistics	Geospatial Decision Support System
TNI Defense	-	-
Geospatial Decision Support System	0.748	-

Table 4 presents the results of the Heterotrait-Monotrait Ratio (HTMT) test used to assess discriminant validity between constructs in the model. The HTMT value between Defense Logistics and Deterrent Strategy is 0.748, which is below the recommended threshold of 0.90. This result indicates that the two constructs are empirically distinct and measure different concepts in the model. In other words, the indicators representing Defense Logistics do not overlap excessively with those representing Deterrent Strategy. This confirms that both variables can be treated as separate constructs while still maintaining a meaningful relationship in explaining how improvements in defense logistics support deterrence strategies through geospatial decision-making in the development of Smart *TNI* Logistics Depots in Papua (Herlia & Harefa, 2024). Table 5 shows that the square root of AVE for Defense Logistics (0.866) and Deterrent Strategy (0.880) is higher than their correlation value (0.690), indicating that the discriminant validity of the constructs in the model is satisfactory.

Table 5. Fornell - Larcker criterion

Variable	Defense Logistics	Geospatial Decision Support System
Defense Logistics	0.866	-
Geospatial Decision Support System	0.690	0.880

3.3 Quantitative stage: Inner model

The results of the hypothesis test indicate that the Defense Logistics (X) variable has a path coefficient value of 0.690, which shows a positive relationship between Defense Logistics and the Geospatial Decision Support System. This positive coefficient suggests that improvements in the defense logistics system in Papua contribute directly to the effectiveness of geospatial-based decision support. In this study, several aspects of defense logistics play an important role, including logistics capacity, the continuity of supply chains, logistics management, and the placement of logistics depots in strategic locations. These elements are closely related to the need for accurate spatial information, as decision-making in complex operational environments such as Papua requires an understanding of terrain conditions, accessibility, and the distribution of operational areas.

Table 6. Hypotesis test

Hipotesis	Path coefficients	*t*-value	*p*-value
Defense logistics has a positive and significant effect on geospatial decision support.	0.690	2.184	0.000

The statistical results further support this relationship. The *t*-value of 2.184, which is higher than the minimum threshold of 1.96, and the *p*-value of 0.000, which is lower than 0.05, indicate that the hypothesis in this study is accepted. This means that the development and strengthening of Defense Logistics in Papua have a positive and significant influence on the need for geospatial data in supporting a Decision Support System. In practical terms, a well-developed logistics system requires reliable spatial information to determine efficient distribution routes, identify strategic depot locations, and support faster operational responses in conflict areas. These findings indicate that defense logistics should not be understood solely as a supply-support mechanism but as a strategic spatial capability that directly influences operational responsiveness in geographically isolated conflict regions.

Table 7. R-Square

	R-square	R-square adjusted
Geospatial Decision Support System	0.476	0.470

Table 7 shows that the R-square value of 0.476 (adjusted 0.470) indicates that Defense Logistics explains about 47.6% of the variation in Deterrent Strategy, suggesting that defense logistics plays a moderately strong role in shaping deterrence capability, although other factors outside the model also contribute. Defense Logistics has a substantial influence on the effectiveness of the Geospatial Decision Support System (GDSS). Table 8 demonstrates that the f^2 value of 0.690 represents a large effect size, indicating that Defense Logistics has a substantial influence on Deterrent Strategy within the research model. This finding suggests that strengthening defense logistics systems plays a critical role in enhancing military deterrence capability, particularly in conflict-prone regions such as Papua. Effective logistics systems support rapid mobilization, sustainable supply chains, operational readiness, and efficient distribution networks, all of which are essential for maintaining security stability. The result also confirms that strategic logistics planning, supported by geospatial decision-making, can significantly improve the ability of the *TNI* to respond to security threats and operational challenges.

Table 8. f-Square

	f^2
Defense logistics to Geospatial Decision Support System	0.690

3.4 Quantitative stage: Model of fit

Table 9 presents the Q^2 predict results used to assess the predictive relevance of the PLS-SEM model. The positive Q^2 predict values for P3 (0.484) and P6 (0.120) indicate that the model has predictive relevance, meaning that the structural model is able to generate meaningful out-of-sample predictions for the observed indicators. The value of P3 shows stronger predictive relevance compared to P6, suggesting that Geospatial Decision Support has a relatively better predictive performance in explaining the related indicator, while the prediction of Deterrent Strategy remains positive but weaker. However, the RMSE and MAE values of the PLS-SEM model are slightly higher than those of the Linear Model (LM), indicating that although the model has acceptable predictive relevance, its predictive accuracy is not yet superior to the benchmark linear model. Therefore, the findings suggest that the proposed model is relevant and useful for prediction, but further refinement may improve its predictive precision and overall model performance.

Table 9. PLS predict

	Q^2 predict	Model PLS-SEM		Model LM	
		RMSE	MAE	RMSE	MAE
P3 <- Geospatial Decision Support	0.484	0.210	0.096	0.167	0.062
P6 <- Deterrent Strategy	0.120	0.269	0.132	0.242	0.116

The analysis results show that the PLS loss value of 0.058 is smaller than the IA loss value of 0.084, with an average loss difference of −0.026, indicating that the PLS-SEM model has better predictive capability than the benchmark model. The t-value of 2.184 and p-value of 0.032 (< 0.05) indicate that this difference in predictive ability is statistically significant. Therefore, the research model that links Defense Logistics with the Geospatial Decision

Support System in supporting deterrent strategy demonstrates good predictive power and can empirically explain how strengthening the defense logistics depot system contributes to the development of Smart *TNI* Logistics Depots in Papua, Indonesia.

Table 10. CVPAT

	PLS loss	IA loss	Average loss difference	*t*-value	*p*-value
Deterrent Strategy	0.058	0.084	-0.026	2.184	0.032

3.5 Geospatial analysis stage based on Geographic Information Systems (GIS)

The geospatial analysis stage in this study was carried out using Geographic Information Systems to examine spatial data related to the geographic conditions of Papua, Indonesia. Papua has a complex physical landscape characterized by mountainous terrain, dense tropical forests, and limited transportation infrastructure, which directly affects the mobility of defense logistics and operational support. To understand these spatial challenges, several datasets were integrated into the GIS analysis, including regional topography, transportation networks such as roads, ports, and airstrips, the spatial distribution of conflict areas, and regional accessibility levels. These datasets were analyzed using several spatial techniques. Overlay analysis was used to combine multiple layers of spatial information in order to identify areas where geographic conditions, conflict distribution, and infrastructure networks intersect. Network accessibility analysis was applied to evaluate the connectivity of transportation routes and to estimate the relative ease or difficulty of reaching operational areas from potential logistics hubs. In addition, location allocation modeling was used to simulate and identify optimal locations for defense logistics depots by considering distance efficiency, accessibility to conflict zones, and proximity to transportation infrastructure (Terribile et al., 2024).

The Figure 3 presents three geospatial analysis maps generated using Geographic Information Systems (GIS) to support the study entitled "Geospatial Decision Support System for Smart *TNI* Logistics Depots in Papua Conflict Zones." These maps illustrate the relationship between the distribution of conflict areas, logistics accessibility networks, and the determination of optimal locations for *TNI* logistics depots in Papua. The first map (Conflict Zones in Papua) shows the distribution of conflict areas concentrated in the Central Highlands of Papua, particularly in the regions of Nduga, Yahukimo, and Puncak. Red areas represent high-intensity conflict zones, while white dots indicate locations of security incidents. The map demonstrates that many conflicts occur in geographically difficult areas such as mountainous regions and dense tropical forests. These conditions make military logistics distribution more complex due to limited transportation access.

The second map (Transportation and Logistics Network in Papua) illustrates transportation infrastructure supporting logistics distribution, including road networks, airports or airstrips, and seaports. Green areas indicate high accessibility, yellow areas indicate moderate accessibility, and red areas indicate low accessibility. The analysis shows that most conflict areas fall within zones of low accessibility, making logistics distribution highly dependent on air transportation. This condition highlights the importance of a more adaptive logistics system capable of reaching remote operational areas(Lü et al., 2019). The third map (Optimal Locations for Smart *TNI* Logistics Depots) presents the results of logistics depot suitability analysis using the Geospatial Decision Support System approach. Green areas indicate locations with high suitability for logistics depot development, while red areas represent low suitability. Red star symbols indicate recommended locations for Smart *TNI* Logistics Depots, blue squares represent conflict areas, and black dots represent existing military bases.

The map indicates that strategically placing logistics depots near conflict zones and major transportation routes can improve logistics distribution efficiency and accelerate *TNI* operational responses in Papua conflict areas. The geospatial analysis results show that conflict areas in Papua are largely distributed in regions with low accessibility, particularly in the Central Highlands such as Nduga, Puncak, and Yahukimo. Network accessibility analysis and location-allocation modeling indicate that most logistics distribution routes still rely heavily on air transportation due to limited land and sea infrastructure. Spatial mapping also reveals that several operational areas have very long logistics distribution distances from the main logistics hub in Jayapura. Therefore, the development of Smart *TNI* Logistics Depots based on a Geospatial Decision Support System is necessary to identify more strategic depot locations based on regional accessibility, proximity to operational zones, and the efficiency of logistics distribution networks (Dmuchowski, 2021).

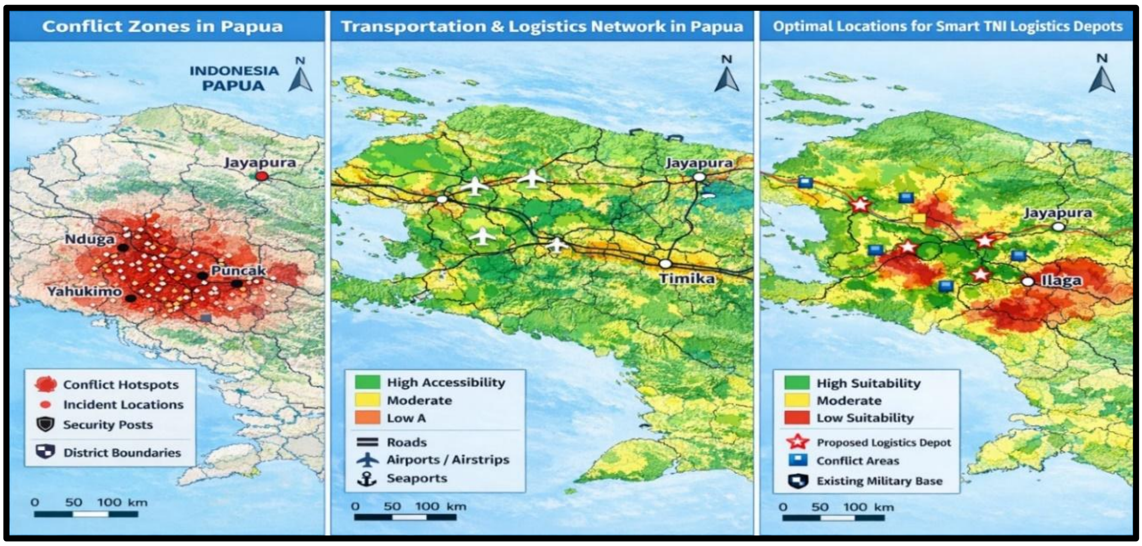

Fig. 3. GIS-Based spatial analysis for smart *TNI* logistics depot planning in Papua conflict zones

3.6 Discussion

The research findings indicate that defense logistics challenges in Papua cannot be addressed solely within the framework of conventional supply management, as the primary barriers are rooted in the spatial characteristics of the region. The effectiveness of defense logistics is strongly influenced by topography, regional isolation, distribution distance, and the limitations of multimodal connectivity. In this context, defense logistics in Papua requires a shift in paradigm from supply-based logistics toward spatially informed logistics, where logistics systems are designed based on accessibility analysis, the distribution of conflict zones, and operational mobility networks.

The findings suggest that the Geospatial Decision Support System should not be viewed only as a technical mapping tool but as a strategic governance instrument within the defense logistics system. The use of GIS, remote sensing, and location-allocation modeling needs to be integrated into planning processes, decision-making mechanisms, and logistics policy priorities. This discussion is important because weaknesses in logistics management in Papua are not only caused by infrastructure limitations but also by the lack of integration between logistics decisions and accurate, real-time spatial data(Bonfante et al., 2024).

Qualitative and geospatial findings indicate that reliance on supply centers from Java Island, Jayapura, and Manokwari makes the defense logistics system in Papua vulnerable to delayed responses, disrupted distribution, and increased operational costs. This suggests the need to reposition the defense logistics structure from a centralized model toward a more distributed, adaptive, and operationally proximate system. In this framework, the development of Smart *TNI* Logistics Depots is not only a matter of efficiency but also part of a strategy to strengthen logistics resilience and reduce strategic vulnerabilities in conflict areas(He et al., 2025).

The SEM-PLS results show is defense logistics has positive and significant effect on geospatial decision support. This indicates that logistics depot locations are not merely storage nodes but strategic elements that influence operational readiness and deterrence capacity. Improved distribution capacity, mobilization readiness, and spatially strategic depot placement enhance the ability of the state to respond quickly and effectively to conflict escalation. This discussion emphasizes that defense logistics should be considered an integral part of an active defense posture rather than merely an administrative support function (Shi et al., 2024).

The study also demonstrates that technological solutions alone are insufficient without policy coordination and institutional integration. The transformation toward Smart *TNI* Logistics Depots requires governance reforms, including synchronization among logistics units, standardization of spatial data, information interoperability, and clear authority in logistics distribution decision-making. Geospatial innovation can only function effectively when accompanied by improvements in governance within the defense logistics system.

The findings are relevant to global geopolitical dynamics, including disruptions to supply chains caused by conflicts in the Middle East. Security challenges in regions such as Papua can no longer be viewed solely as domestic issues because defense logistics stability is also influenced by external dynamics such as energy prices, global trade routes, and vulnerabilities in strategic supply chains. Therefore, the development of geospatial-based defense logistics systems in Papua can be understood as a local response to global security challenges, expanding the discussion on the relationship between defense logistics, spatial analysis, and national resilience (Dmuchowski, 2021).

The R^2 value of 0.476 suggests that defense logistics explains a significant portion of the effectiveness of geospatial decision systems and deterrence strategies but does not account for all influencing factors. Other variables, such as institutional capacity, budget support, dual-use infrastructure quality, local security dynamics, and civil–military coordination, may also influence the planning of strategic logistics depots in Papua. This finding opens opportunities for future research to develop more comprehensive and multidimensional models.

Overall, the most important contribution of this study lies in positioning defense logistics in conflict areas as a spatially informed decision system. The integration of qualitative analysis, quantitative validation, and GIS-based spatial modeling provides a stronger foundation for determining strategic logistics depot locations. This expands academic discussions from the general importance of defense logistics toward the role of geospatial decision support systems as a foundation for modernizing *TNI* logistics management in Papua.

The strength of this study lies in its integration of qualitative, quantitative, and geospatial GIS-based analyses within a single Geospatial Decision Support System framework for planning Smart *TNI* Logistics Depots in conflict areas of Papua. However, the study is limited because the model does not yet incorporate additional factors beyond defense logistics, such as budget allocation, local political dynamics, inter-agency interoperability, and more detailed operational spatial data. In addition, the recommended logistics depot locations were generated through GIS-based spatial modeling and have not yet undergone direct operational field validation in Papua conflict areas.

4. Conclusion

The development of a Geospatial Decision Support System (GDSS) based on geoinformatics technologies, including Geographic Information Systems (GIS), transportation network analysis, and location-allocation spatial modeling, proves to be an effective approach for determining strategic locations for the construction and development of Smart Defense Logistics Depots in Papua. The qualitative analysis shows that many areas in Papua are characterized by limited accessibility and complex topography, making conventional logistics distribution and development systems less effective in supporting the mobilization and distribution of defense logistics for *TNI* personnel operating in Papua, as well as for territorial development activities. By integrating spatial analysis with local topographic data and accessibility conditions in areas prone to security disturbances, the Geospatial Decision Support System model is able to identify more optimal and strategic locations for the development and construction of defense logistics depots. This approach supports more efficient logistics distribution for *TNI* operations and enables faster operational responses for both public needs and potential threats such as natural disasters.

The results of the quantitative analysis indicate that strengthening the defense logistics system has a positive and significant effect on the effectiveness of geospatial-based decision-making systems. These findings confirm that the integration of logistics readiness and capacity with spatial analysis technology is an important factor in improving *TNI* operational responsiveness and readiness, strengthening territorial development for public interests and national defense, and maintaining regional security stability. This study has several limitations. First, the qualitative phase involved a limited number of expert participants, which may restrict the generalizability of conceptual findings. Second, the SEM-PLS model explains only part of the variance in geospatial decision-support effectiveness, indicating that other operational and institutional variables may also influence defense logistics planning. Third, the recommended logistics depot locations have not yet undergone direct field validation, which should be considered in future operational studies. This study concludes that the use of geoinformatics technology through the Geospatial Decision Support System not only improves the effectiveness of planning defense logistics depot development in Papua, but also provides strategic benefits in strengthening a defense logistics system that is more adaptive to local, domestic, and regional challenges, as well as to evolving global geopolitical dynamics, including the impacts of the conflict between the United States-Israel and Iran in the Middle East.

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