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# Determination of Cross-Border Post Points Based on Geospatial Intelligence for Territorial Defense of the Unitary State of the Republic of Indonesia: Literature Review

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A R T I C L E I N F O

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A B S T R A C T

The location of cross-border posts is crucial for Indonesia's land and maritime security and combating illegal activity. Geographical intelligence technology like sensors and machine learning can help find crucial sites. GEOINT and international cooperation enable monitoring, threat detection, and trade regulation. This study uses a literature review to examine how GEOINT helps Indonesia defend its territory. This research collects, analyzes, and synthesizes important scientific studies using a literature review. Our literature search used relevant terms in scientific databases. The selected literature covers GIS, GEOINT, Satellites, Drones, and cross-border posts. Analysis identified major conclusions and research gaps. Geospatial intelligence technology (GEOINT), which uses drones and satellites to monitor and provide high-resolution data, is effective at detecting and responding to threats in Indonesia's extensive border areas. Additionally, this technology helps find the right cross-border post. Geographic information systems (GIS) must assist centralized data management and defense agency collaboration to strengthen border security. GEOINT supports strategic cross-border post placement decisions to secure Indonesia's borders. For regional defense, national security, and stability in the face of complex global problems, the latest and most effective technologies must be developed and used.

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## INTRODUCTION

Determining the location of cross-border posts is very important to protect Indonesia's vast land and sea areas, which directly border several countries. It is critical to have an effective method for determining the location of these posts to improve border security and prevent illegal activities such as border crossings, drug smuggling, human trafficking and terrorism. To evaluate vulnerability to terrorism, a spatial multi-criteria analysis can be carried out taking into account various factors, such as the location of previous attacks, where terrorists were captured, and the presence of military and police facilities. This analysis helps in identifying and prioritizing areas that are more vulnerable to terrorist activities, thereby assisting strategic decision making about security measures (Supriyadi et al., 2020). Geospatial intelligence technology, driven by perception capabilities, can be used to pinpoint these strategic locations accurately and effectively. This involves the use of sensors, machine learning, encryption, cameras, robotics, and cloud computing (J. Dold et al., 2017). Another example of the use of GIS is useful for determining the development of the defense industry in Indonesia, where the combination of GIS and remote sensing techniques has proven to be very effective in determining land suitability for various strategic industries (Supriyadi et al., 2019).

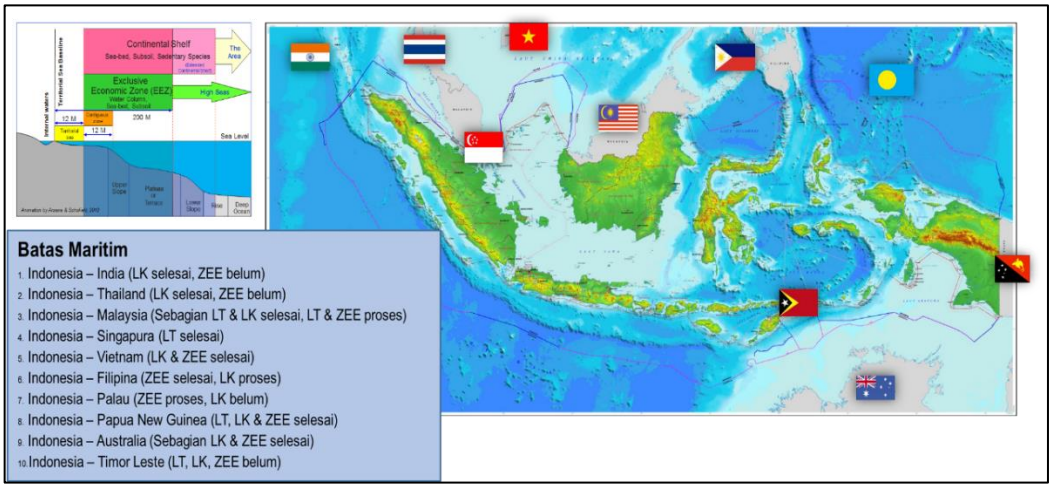


Figure 1. Status of land and maritime borders with neighboring countries (Source BIG 2024)

Indonesia's border regions face various threats, both conventional such as infiltration and military attacks, and non-traditional such as refugees, smuggling, human trafficking, drug trafficking, and violations of sovereign rights (Hede Uly et al., 2023). Cross-border posts are very important to maintain the country's security and sovereignty. International cooperation on security issues involves organizing border crossings, sharing information, and coordinating military efforts (D. Fieni et al., 2014). Appropriate deployment of resources allows for better law enforcement, increased surveillance, and early detection of threats in vulnerable areas. In addition, cross-border posts facilitate monitoring of the flow of people and goods between countries.

## THEORETICAL REVIEW

Geospatial Intelligence (GEOINT) has become an essential instrument in contemporary defense strategy, especially concerning border security. GEOINT employs the combination of geographic information systems (GIS), remote sensing, satellite imaging, and drone technologies to effectively monitor and manage territorial boundaries. This theoretical assessment will delineate the fundamental principles underpinning the application of GEOINT in identifying cross-border post locations, emphasizing critical theories associated with geographical analysis, security studies, and technological integration within defense systems.

### *Geospatial Analysis and Geographic Information Systems*

Spatial analysis is fundamental to geospatial intelligence, facilitating the processing and interpretation of geographical data. Geographic Information Systems (GIS) offer the structure for acquiring, storing, and analyzing spatial data. Defense agencies can utilize GIS to delineate topography, identify susceptible locations, and simulate potential threats. Spatial multi-criteria analysis (SMCA) facilitates the assessment of aspects including proximity to previous incidents, geography, and accessibility, which are essential for strategic decision-making (Supriyadi et al., 2020).

### *Theories of Security and Threat Detection*

National security theories underscore the significance of border management in deterring unauthorized movements, such as unlawful crossings, smuggling, and terrorism. GEOINT corresponds with these theories by augmenting surveillance capabilities via real-time monitoring devices, such as drones and satellites. The deterrence theory is applicable, as efficient border surveillance serves as a deterrent to illicit operations. Moreover, threat detection models enhanced by GEOINT technologies provide proactive responses to security threats, hence augmenting situational awareness and military readiness (Dold et al., 2017).

### *Incorporation of Technology in Defense Systems*

The incorporation of sophisticated technology, including machine learning, sensors, and remote sensing, enhances the efficacy of GEOINT in contemporary defensive operations. Technological convergence, wherein many systems collaborate to augment operational capabilities, is a fundamental theory in this setting. Drones deliver real-time data from inaccessible locales, whereas satellites provide a macro-level perspective of border regions, enabling security agencies to integrate information from many sources to develop a unified defensive strategy. This tiered strategy guarantees extensive coverage and meticulous local oversight, consistent with networked defensive system ideas (Rizki & Surya, 2021).

### *Coordinated Border Management (CBM)*

The Coordinated Border Management (CBM) hypothesis posits that efficient border security necessitates collaboration among diverse authorities and international stakeholders. GIS and GEOINT technologies enable centralized

data administration, promoting real-time data sharing and enhanced coordination across military, police, and customs officials. This theory emphasizes the significance of inter-agency collaboration in the effective and secure management of borders (Setiawan et al., 2020).

***Assessment of Risk and Vulnerability***

Theories of risk assessment concentrate on recognizing and alleviating dangers influenced by geographic, environmental, and social variables. GEOINT improves risk assessments by supplying real-time data and predictive algorithms to evaluate the risks of various border zones. Terrain analysis identifies regions with difficult accessibility, and weather modeling forecasts conditions that may impede surveillance operations. This corresponds with risk management theories that emphasize the anticipated and proactive mitigation of dangers via data-driven insights (Yusfan et al., 2021).

## METHODOLOGY

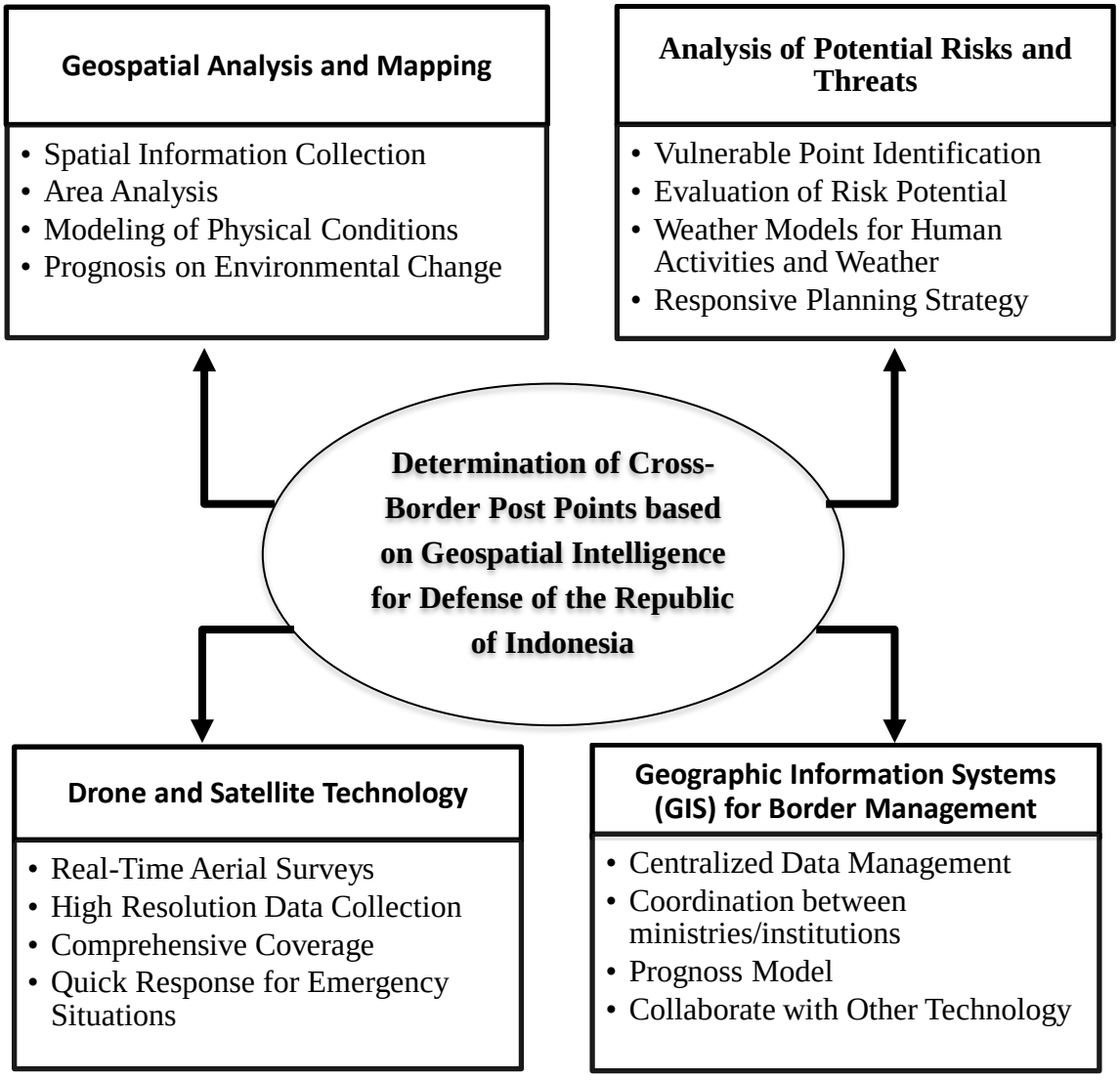


Figure 2. Brainstorming

The research method used is a literature review, namely the collection, analysis and synthesis of various scientific studies related to the use of geospatial intelligence. A literature review is carried out by determining the topic and looking for previous research journals and other documents that will be used as sources for analysis. The results of the collection of analysis sources are selected and selected based on the latest research. Next, the sources are grouped based on main topic and subtopic categories. This research examines the contribution of satellites in communication systems, disaster monitoring and rescue, regional border monitoring, as well as intelligence and monitoring of military activities or threats. The following is a study idea that was shown in Figure 2.

## RESULTS

### *Analysis of Potential Risks and Threats*

Standardization of the construction of National Border Posts (PLBN) will encourage safer and more orderly border management and increase cross-border security and cooperation (Rachmawati Novaria et al., 2019). Risk analysis in border areas begins with identifying vulnerable points. In this process, terrain analysis is carried out to identify areas that are difficult to monitor or guard. Mountain passes that are difficult to access, dense forest areas, or water areas that are often used for smuggling are some vulnerable locations. Indonesia's maritime border security faces many problems, including cross-border criminal activities and unresolved border conflicts with neighboring countries (Fauzan et al., 2019). To increase security, information about defense in border areas is needed (Irdayanti et al., 2022). These places are usually infiltration routes or possible attack locations. To set monitoring priorities and more efficient resource allocation, it is critical to discover vulnerable areas. For example, routes in difficult-to-reach mountains may require additional monitoring through the use of drones or advanced sensors.

After a vulnerable point is found, the next thing is to evaluate the potential risk of threats that may occur in that area. Because it includes elements such as geography, weather, and human activity, geospatial data is critical to these assessments. For example, areas with difficult terrain could become targets for attacks, while extreme weather could impact cross-border post operations. Thorough risk evaluation allows for better planning and better response to risks. Indonesia has addressed public security issues in the Indonesia-Malaysia border region after assessing risks at the border by increasing presidential visits, improving infrastructure, and improving public policies (Ningtias et al., 2018). In situations like these, GIS can help integrate multiple data sources to create accurate and detailed risk maps. Geospatial Intelligence Analysis (GEOINT) finds terrorist hideouts in mountainous areas, which helps national defense (Supriyadi et al., 2020) (Utomo et al., 2021) (Yusfan et al., 2021).

Weather modeling is used to predict weather conditions that can affect cross-border postal operations. Extreme weather such as storms, floods, or dense fog can make monitoring and responding to threats difficult. Modeling human activities, such as population movement patterns or trade activities, is also important for understanding dynamics in border areas. Geospatial techniques,

which combine remote sensing data, global positioning systems, and geographic information tools, can help sustainable land use planning and agricultural mapping, which includes analysis of human activity and weather (Sugianto et al., 2021). This analysis helps spot suspicious or unusual activity that could indicate a threat. For example, a sudden increase in trafficking activity in a particular area may indicate that smuggling requires stricter controls.

Based on risk and threat analysis, PLBN placement can be optimized by carrying out proactive and responsive planning. This strategy includes placing posts in strategic locations to monitor vulnerable points and potential infiltration routes. Indonesian government policy focuses on developing cross-border areas with Malaysia to combat military and non-military threats and support the defense economy (Septyana & Sundari, 2022). Furthermore, a Coordinated Border Management (CBM) strategy must be implemented to secure borders in accordance with the needs of globalization and national interests (Setiawan et al., 2020). Training and simulations to increase the readiness of officers and troops in the PLBN as well as the development of standard operational procedures (SOP) adapted to various threat scenarios are also very important. Therefore, GIS can be used to design plans that can be quickly adapted to changing field conditions.

One of the important steps in determining strategic PLBN points for the defense of the Republic of Indonesia's territory is analyzing potential risks and threats using geospatial intelligence (Yusfan et al., 2021). By identifying vulnerable points, evaluating potential risks, modeling human activity and weather, and planning responsive strategies, GIS provides a strong foundation for strategic decision making.

***Geospatial Analysis and Mapping***

Analysis and mapping of border areas using GIS is very important to find strategic border crossing points. This technique identifies, analyzes and models geographic conditions with spatial data. This method is used to make better defense and security decisions.

The first step in geospatial analysis is the collection of spatial information. Spatial data is collected from field surveys, topographic maps, satellite images, and LIDAR (Light Detection and Ranging) data. To support various applications, including national security, Indonesia's geospatial data infrastructure requires the integration of geospatial data players, standardized maps, and integrated information technology infrastructure (Karsidi, 2017). In addition, geospatial analysis can be used to determine the existence of public places of worship and their impact on the surrounding environment. This can help reduce social conflicts caused by its existence (Crysdian, 2013). Topographic maps show the contours and elevation of the land, which is important for terrain analysis. LIDAR data shows height and surface structure, while satellite imagery provides a broad visual picture of regional conditions (Sutanta, Aditya, & Astrini, 2016). Additionally, the spatial data collection process involves the use of sensor and drone technology to obtain accurate data in real time. Drones have the ability to fly over hard-to-reach areas and collect infrared and visual data. This data is then combined with other geospatial data (Rizki & Surya, 2021). This collected data is

used to create interactive and detailed digital maps that enable a more comprehensive analysis of border areas.

An important process for determining strategic locations for PLBN. Geographic Information Systems (GIS) software enables the creation of interactive digital maps, where multiple layers of data can be displayed and analyzed simultaneously to identify strategic locations. Area analysis is very important to support national defense interests because it includes evaluation of topographic components that can influence the effectiveness of cross-border posts, such as visibility, accessibility and natural protection (Syetiawan et al., 2019). Terrain that is difficult for outsiders to access provides defensive advantages, but high-visibility locations allow for better surveillance. Area analysis also looks at vegetation, soil type and surrounding infrastructure (Heri, Diyono, & Deva, 2018).

With geospatial data, you can create models that describe the geographic conditions of an area. The ideal defensive viewpoint location is found through elevation and slope analysis. Locations that have high visibility are very important because they allow better monitoring (Aminah & Anjasmara, 2021). To ensure that cross-border posts can be established and operated properly, this analysis also considers accessibility and terrain conditions. In addition, physical condition modeling includes examining variables such as vegetation, soil type, and weather conditions that may affect the operation and maintenance of cross-border posts (Crysdian, 2013).

This prognosis uses geospatial data to predict environmental changes that may affect border areas. Analysis of the impact of climate change on border areas is also included in forecasting environmental change. According to Amnah Elaji et al. (2020), an increase in the frequency and intensity of extreme weather, such as storms and floods, can impact the operation and security of cross-border posts. Planners can create better adaptation strategies to maintain border region security by modeling the impacts of climate change (Jorge A. Duran-Encalada et al., 2017).

Geospatial analysis and mapping are very important to determine strategic cross-border post points for the defense of the Republic of Indonesia's territory. Area analysis, carried out by collecting spatial information from various sources, allows for accurate and detailed mapping. Prognosis of environmental changes helps with long-term planning and decision-making, while modeling of physical conditions provides the data necessary to establish and operate cross-border posts efficiently.

***Drone and Satellite Technology***

For defense purposes, drone and satellite technology have become important tools in collecting geospatial data, increasing land border security, but reliability and responsibility still need to be confirmed (Shishkov & Hristozov, 2017).

One of the main advantages of drones is the ability to conduct real-time aerial surveys. Drones can collect data from the air quickly and efficiently by having various sensors, such as lidar, infrared cameras and visual cameras. This

capability is especially important in cases where time is of the essence, such as monitoring borders or responding to threats (Rizki & Surya, 2021). However, drones have been used to manage borders in Europe (Csernatoni, 2018). Drones can provide real-time data that is critical for quick decision making because they can fly at low altitudes and reach locations that are difficult for humans to access. Drones can directly transmit data to command centers, allowing officials to view the situation directly and immediately take necessary action. For example, drones can be immediately sent to locations to capture real-time images and videos, which will help in quick reactions when enemy elements detect an intrusion (Xavier & Anwar, 2021).

Modern satellites have advanced sensors that can collect data at a very high level of detail, including radar images, optical images and other spectral data, which is very useful for monitoring and analyzing large border areas. This data allows accurate mapping of physical conditions and activities around the border. By using satellite technology, the security of national parks on the Indonesia-Malaysia border can be improved (Saptono et al., 2021) (Sudagung, 2021). The electric line battery charging system can be used on drones for longer periods of time so that they can be used during border patrols (Kim & Lim, 2018). Having high-resolution data from satellites allows better identification and analysis of possible threats. For example, satellites can observe small changes in territory, such as unlawful infrastructure construction or suspicious human activity. Because these data allow further evaluation of terrain and environmental conditions, they are also useful for planning and positioning cross-border posts (Mariani & Nugroho, 2020). High resolution data from satellites can also be used to observe changes in border areas over the long term. Temporal analysis of satellite images can be used to monitor infrastructure development, population movements, and changes in land use patterns. This helps the defense government create a long-term strategy (Nurhayati & Syamsuddin, 2022).

The coverage that can be achieved by the combination of drone and satellite technology is one of its main advantages. While drones can be used to conduct specific surveys in a particular area, satellites provide a broader view of bordering areas. By combining data from these two sources, more comprehensive and accurate monitoring can be carried out (Arief, 2022). While satellites ensure that entire border areas remain monitored, drones can fly over hard-to-reach areas and transmit high-resolution data locally. This is critical for identifying hazards that may not be detected with conventional surveillance techniques. Defense can ensure that no areas are overlooked and that all potential threats can be identified and dealt with quickly with comprehensive coverage (Luerdi & Wahyudi, 2021).

Rapid Response Drones for Emergency Situations have the ability to fly quickly to threat locations and collect images and videos in real time, which enables fast and precise responses to threats (Fauzan, Abdullah, & Ahmad, 2019). By providing real-time actionable intelligence and the ability to survive in harsh environments and remote settings, the combination of drone surveillance and sensor-based detection enhances border security (Sharma et al., 2021). In

addition, drones can be used in natural disasters such as floods or landslides to assess damage and assist in rescue (Eko & Irawan, 2022).

By integrating data from drones and satellites into a Centralized Data Management System, these two technologies offer innovative solutions for monitoring and analyzing border areas in the context of the Republic of Indonesia's territorial defense. With real-time aerial survey capabilities, high-resolution data collection, comprehensive coverage, and rapid response to emergency situations, these two technologies provide strategic advantages in maintaining regional sovereignty and security. By continuing to develop and use this technology, the territorial defense of the Republic of Indonesia can be significantly strengthened, ensuring national security and stability amidst increasingly complex global challenges.

*Geographic Information Systems (GIS) for Border Management*

Geographic Information Systems (GIS) are important tools in border management that assist in the collection, storage, analysis and visualization of spatial data to support strategic decision making (W. Tao et al., 2013). The main advantage of using GIS in border management is the ability to manage data centrally. GIS can be used by the Ministry of Defense (Kemhan) to collect and store data from various sources in one integrated system (G. Pierce et al., 2002). Topographic maps, satellite imagery, LIDAR data, and other field information are included in this data. By storing all data in one centralized system, the Ministry of Defense can ensure that important information is always available and that authorized parties can easily access it (Sugianto et al., 2021). In addition, centralized data management ensures that the information used for strategic decision making is consistent, which reduces the risk of data duplication (Shunrong Jiang et al., 2020).

Coordination between Ministries/Agencies (K/L) is very important for effective border management. GIS allows various Ministries/Agencies to share data and information in real-time, improve coordination and cooperation in maintaining border security, and enable better handling to improve border security through geospatial intelligence (Utomo et al., 2021). In addition, this makes it easier to carry out and plan joint operations in a more organized and effective manner (Irdayanti, Salmiyati, & Nurlita, 2022).

Prognoss Models: An important tool in strategic planning, prognoss models are used to predict enemy movements or illegal activities in border areas. Factors that can help make strategic decisions are data aggregation, prediction methods, and data collection (Yuri Romanenkov et al., 2016). These models can help determine when and where smuggling or infiltration is most likely to occur, allowing defense authorities to allocate resources more efficiently. Prognostic models predict weather conditions, human activities, and geographic patterns. For example, analysis of data about human activity can help spot suspicious changes in behavioral patterns, and analysis of weather data can help predict when extreme weather may hinder surveillance. Therefore, the prognosis model allows more proactive and responsive planning for possible dangers (Cahyadi & Pristiyanto, 2021).

Collaborate with Other Technologies: GIS can collaborate with different technologies to improve border management efficiency. A multilayer hybrid architecture combining cameras, scalar sensors, radar and UAVs can improve border surveillance by detecting intrusions and managing networks (Mohamed Lamine Laouira et al., 2021). In addition, integration of data from ground sensors such as motion or infrared sensors, which can detect suspicious activity in border areas (Ezgi Karabulut et al., 2017). Next, this data can be analyzed using GIS to find patterns and trends that indicate threats. Additionally, GIS can be used in conjunction with command and communications systems, allowing better coordination between defense and security units. By working together with other technologies, GIS can provide a more accurate picture of conditions in border areas. This improves defenses' ability to make better, faster decisions, and improves their ability to respond better to threats. Additionally, technology integration makes supervision and monitoring easier. This ensures that all border areas are well monitored and threats can be detected quickly (Zhi Sun et al., 2011).

To protect the territory of the Republic of Indonesia, increasing the capability of the Geographic Information System (GIS) with other information can be called Geospatial Intelligence (GEOINT) in border management. The use of geospatial technology to determine geographic shape, location, or location on a large spatial scale is known as geospatial intelligence (Wang et al., 2024). The Ministry of Defense can collect, store and analyze data from various sources through the use of centralized data management. The use of GEOINT improves coordination between Ministries/Agencies (K/L), enabling various parties to share data and information in real-time. Prognostic models created with GEOINT help in strategic planning by predicting enemy movements or illegal activities. Collaboration with other technologies such as drones and satellites enhances surveillance and monitoring, ensuring that all border areas are well monitored and threats can be detected quickly.

The use of GEOINT increases surveillance and reaction capabilities to threats and maintains territorial sovereignty. Threats to national defense can come from military or non-military sources (Utomo et al., 2021). By continuing to develop and utilize geospatial technology, the Republic of Indonesia's territorial defense can be significantly strengthened to ensure national security and stability amidst increasingly complex global challenges.

## CONCLUSION AND RECOMMENDATION

In the territorial defense of the Republic of Indonesia, the use of GEOINT has many significant strategic benefits. GEOINT provides a strong basis for strategic decision making in maintaining border security by identifying vulnerable points, evaluating potential risks, modeling weather, and developing responsive planning strategies. Coordination between Ministries/Agencies (K/L) improves collaboration and reaction to threats, while centralized data management by the Ministry of Defense allows easy access and comprehensive analysis. Drone and satellite technology provides comprehensive coverage of border areas and high-resolution data in real-time, enhancing survey capabilities.

While satellites provide a bird's-eye and detailed view of physical conditions and activities on the ground, drones enable rapid response in emergency situations.

By combining data from drones and satellites into GEOINT, surveillance and analysis become more effective. This allows all relevant information to be used to respond to threats quickly and appropriately. Overall, the use of geospatial technology in the defense of the Republic of Indonesia's borders not only increases the country's security and stability but also makes it possible to act more proactively and responsively to various threats. This technology provides powerful tools to better plan and manage border areas, safeguard national sovereignty, and ensure the safety of citizens amidst increasing global challenges. Indonesia can use this technology to strengthen its position as a safe and sovereign country that can quickly and efficiently deal with various threats and emergency situations.

## FURTHER STUDY

Future studies could investigate the incorporation of developing technologies, such as artificial intelligence (AI) and machine learning (ML), to improve the accuracy of geospatial intelligence (GEOINT) for border security. This may entail employing predictive analytics to anticipate potential security threats in real-time and enhance the positioning of cross-border installations. Furthermore, evaluating the enduring effects of environmental elements such as climate change on border vulnerabilities might yield significant insights for sustainable defence tactics.

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