

Digital Transformation in Foreign Surveillance: A Systematic Literature Review (SLR) of the Role of Geospatial Intelligence

Prima Setiawan^{1,*}, Hari Purwanto², Budi Prasetyono³, Somantha Prakosa Jati⁴

^{1,2,3} Department of Intelligence Studies, State Intelligence College (STIN), Sumur Batu, Kec. Babakan Madang, Kabupaten Bogor, Jawa Barat 16810, Indonesia

⁴ Planning Bureau, Main Secretariat at National Agency for Disaster Countermeasure (BNPB), Jl. Pramuka Kav. 38, Jakarta Timur 13120, Indonesia

* Corresponding author : prima.xvi@gmail.com

Tel.: +62 819-0869-8033

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Abstract

Surveillance of foreigners is essential in maintaining Indonesia's national stability and security, given the increasing global migration mobility. Digital transformation and the application of geospatial intelligence (Geoint) are potential solutions to improve the detection and early response to threats brought by foreign nationals (WNA). This study aims to evaluate the effectiveness of geospatial intelligence (Geoint) in enhancing the surveillance of foreign nationals (WNA) within the context of Indonesia's national security and stability. This study uses a Systematic Literature Review (SLR) based on the PRISMA 2020 guidelines, with literature searches on Scopus and Google Scholar until May 10, 2024. The selected studies focused on the use of Geoint in relation to immigration and national security surveillance, while studies that were irrelevant or not available in full text were excluded. The findings indicate that Geoint significantly enhances surveillance capabilities by enabling rapid, precise monitoring and early threat prediction. Notably, Geoint facilitates the analysis of movement patterns of foreign nationals and the identification of high-risk areas, thereby increasing operational efficiency and targeting accuracy. For instance, it supports proactive responses to espionage-related activities—defined as the illicit gathering of sensitive information—that pose a risk to national security. The study concludes that integrating Geoint into immigration surveillance systems represents a strategic advancement in Indonesia's digital security infrastructure. For policymakers and security practitioners, this innovation underscores the need for adaptive, data-driven surveillance frameworks that can respond dynamically to evolving migration patterns and security threats. Future national security policies should consider institutionalizing Geoint as a core component of foreign surveillance strategy.

Keywords: Diffusion of Innovation, Digital Transformation, Foreign Surveillance, Geospatial Intelligence, Systematic Studies.

1. Introduction

In an increasingly interconnected world, the movement of people across borders has become a defining characteristic of the global era. Every year, millions of individuals travel across countries for tourism, trade, work, and refuge. For instance, in 2023, Indonesia recorded more than 6.5 million foreign nationals entering the country through just five major immigration checkpoints, highlighting the scale and importance of immigration surveillance in ensuring national security and facilitating economic growth (Table 1). This growing volume of cross-border mobility underscores the pressing need for effective immigration governance.

Table 1. Foreigner's Arrival at 5 Biggest Immigration Checkpoints Year 2023

No	Immigration Checkpoints	Foreigner's Arrival
1	Ngurah Rai Airpot	4.666.731
2	Soekarno-Hatta Airport	1.106.252
3	Batam Center Seaport	507.575
4	Juanda Airport	175.157
5	Kualanamu Airport	123.680
	Total	6.579.395

Source: katalog.data.go.id (Ministry of Communication and Information of the Republic of Indonesia, n.d.)

Globalization, driven largely by advances in transportation and communication technologies, has

significantly enhanced global mobility. Airplanes, high-speed trains, and digital connectivity have diminished geographical barriers, enabling the movement of people, goods, and ideas at unprecedented speeds (Janelle and Beuthe, 1997; Vaziri and Rezaee, 2008). While this fosters economic integration and cultural exchange (Nijkamp, 2003), it also introduces new challenges in managing immigration, especially for geographically complex nations like Indonesia.

As an archipelagic nation with a vast and dispersed population, Indonesia faces distinct hurdles in regulating the mobility of both its citizens and foreign nationals. Major urban centers such as Jakarta and Surabaya experience high levels of internal mobility due to rapid urbanization, whereas remote and border regions remain underserved and vulnerable to unregulated movement (Rodrigue, 1999; Khorniawan et al. 2024; Jannah et al. 2024). Additionally, Indonesia has become both a destination and transit country for immigrants seeking economic opportunities or fleeing from political instability (Richmond, 2002).

The influx of immigrants brings both opportunities and risks. On the one hand, foreign nationals contribute to Indonesia's economy through labor, tourism, and investment (Burnett, 2002; Romzah, 2023). On the other, their presence can create challenges such as labor competition, social tensions, and threats to public order and national security (Xu, 2007; Jetten, 2019). In 2024 alone,

1,761 foreign nationals were subject to immigration administrative actions, and 52 faced criminal investigations related to immigration violations ([Detik.com, 2024](#)).

The Directorate General of Immigration, under the Ministry of Law and Human Rights, plays a central role in executing immigration functions, which include services, law enforcement, national security, and public welfare facilitation. The increasing complexity of immigration issues demands not only legal and policy responses but also the integration of innovative technologies. Among these, Geospatial Intelligence (GEOINT) offers a promising solution. GEOINT combines spatial data with intelligence practices to support decision-making, particularly in monitoring border movements and identifying potential threats ([Walsh, 2013](#)).

GEOINT has already proven effective in contexts such as the United States, where it has been used to map smuggling routes and optimize border control resource allocation. In Indonesia, integrating such technology could help overcome current limitations in surveillance, especially in remote and high-risk areas. However, adopting GEOINT involves navigating institutional, technical, and resource-related challenges that require strategic planning and inter-agency collaboration. Spatial technology is useful in various fields

This paper adopts Diffusion of Innovation Theory ([Rogers, 2003](#)) to understand how geospatial intelligence can be introduced and scaled within Indonesia's immigration system. According to this theory, innovations spread in stages—starting with early adopters before reaching wider acceptance. Applying this framework helps explain how major immigration checkpoints like Ngurah Rai and Soekarno-Hatta could pioneer the adoption of GEOINT before expanding nationwide.

Using a literature review approach, this study synthesizes existing research on immigration surveillance and geospatial intelligence, particularly in the context of Indonesia. This method enables a critical analysis of past studies, identification of gaps, and assessment of the potential for GEOINT adoption. Complementing the literature review, observational studies on current surveillance practices are employed to compare the effectiveness of traditional methods against the advantages offered by geospatial intelligence. This paper argues that the integration of geospatial intelligence (GEOINT) into Indonesia's immigration surveillance systems offers a transformative opportunity to enhance national security and immigration governance—provided that key institutional, infrastructural, and innovation diffusion challenges are effectively addressed.

2. Related Work

2.1 Diffusion of Innovation

The Innovation Diffusion Theory, introduced by Rogers (2003), is widely employed to understand how individuals and organizations accept innovation. This theory provides a framework for discussing global acceptance and views innovation as being transferred through specific channels over time within a particular social system ([Rogers, 2003](#)). Innovation, as defined by Rogers (2003), encompasses ideas, practices, or objects perceived as new by individuals or other adopters. The process of diffusion, also defined by Rogers (2003), involves the communication of innovation within a social system and its subsequent adoption or rejection by its members.

In his work, Rogers (2003) articulated five key attributes that influence the rate at which an innovation is adopted, namely: relative advantage, compatibility, complexity, trialability, and observability. The relative advantage of an innovation pertains to its perceived superiority over existing ideas. Compatibility refers to the extent to which an innovation aligns with established values, beliefs, experiences, and needs. Complexity is associated with the risks involved in comprehending and utilizing the newly introduced concept. Trialability denotes the ease with which an innovation can be experimented with. Observability concerns the visibility of the results of an innovation. Furthermore, Rogers classified innovation adopters into five distinct categories based on their timing of adoption: innovators, early adopters, early majority, late majority, and laggards ([Rogers, 2003](#)).

Innovation adopters within public institutions can be categorized based on how policies are delivered. How policies are delivered within intra-organizational public institutions can be understood by examining the interplay between organizational culture, hierarchical structures, and communication channels ([Rogers, 2003](#); [Valente, 1996](#)). These elements not only influence how policies are communicated but also affect the rate and type of adoption among different groups within the organization. Combining Rogers (2003) adopter's categories and the elements of how policies are delivered ([Rogers, 2003](#); [Valente, 1996](#)), several categories fit the innovation adopters in public institutions:

a. Policy Champions (Innovators)

These are the individuals who actively push for the adoption of new policies and innovations. They are typically early advocates, influencing others through formal and informal channels. In public institutions, they might be higher-level officials or individuals who are well-connected across departments ([Rogers, 2003](#)). They often play a key role in piloting new policies, promoting their benefits, and leading change initiatives ([Zhou, 2008](#)). Their influence is critical in getting others on board ([Zhou, 2008](#)).

b. Institutional Gatekeepers (Early Adopters)

Gatekeepers are those who have early access to the policy through decision-making roles but are cautious in their approach ([Valente, 1996](#)). They may need to see some initial evidence of success or political support before fully embracing the change ([Zhou, 2008](#)). They are respected within the institution and often provide feedback that helps shape the implementation process ([McWhorter et al., 2013](#)). This group helps refine the policy and make it practical for broader adoption ([McWhorter et al., 2013](#)).

c. Operational Adopters (Early Majority)

These adopters represent a large group of middle-management or operational staff who implement the policy as part of their everyday responsibilities. They may not be involved in shaping the policy but adopt it once it becomes institutionalized and after it has been validated by early adopters ([Rogers, 2003](#)). This group tends to follow established procedures and looks for guidance from the gatekeepers before fully engaging with the policy ([Frambach and Schillewaert, 2002](#)). Their adoption is critical for widespread implementation across the organization ([Frambach and Schillewaert, 2002](#)).

d. Compliance Adopters (Late Majority)

This group adopts the policy only after it becomes clear that it is mandatory and non-compliance could lead to consequences ([Oser and Roman, 2008](#)). They typically wait until there is no option but to follow the policy, often needing clear direction from leadership or higher

authorities (Rogers, 2003). They adopt policies because of external pressures or organizational directives rather than an intrinsic belief in innovation (Valente, 1996). They may need extra support and training to ensure they can properly implement the policy (Zhou, 2008).

e. Resistant Adopters (Laggards)

Resistant adopters are those who adopt the policy only as a last resort or under direct pressure from supervisors or mandates (Zhou, 2008). They may actively resist change due to skepticism about the policy's benefits, concerns about increased workloads, or a preference for the status quo (Rogers, 2003). In public institutions, these individuals may also be influenced by deeply rooted organizational norms or political considerations (Frambach and Schillewaert, 2002). This group requires significant encouragement, training, or even incentives to fully adopt the policy (Valente, 1996).

2.2 Immigration

The concept of immigration or international migration arises from the concept of the state and its sovereignty. The qualifications that a territory must have to become a state are (a) a permanent population; (b) a defined territory; (c) a government; and (d) the capacity to establish relations with other countries (Montevideo Convention Montevideo Convention.pdf., n.d.). To have the capacity to establish relations with other states, a state must have sovereignty that is recognized by other states. Sovereignty is defined as the highest authority over a territory (Philpott, 2020), further explaining that a state has the highest authority within its territory to do everything necessary to govern itself.

In relation to migration, state sovereignty governs and regulates the conditions under which a person migrates into the state's territory. If a territory has achieved statehood, then the movement or migration of people into the territory from outside constitutes international migration or immigration. Otherwise, the migration that takes place is referred to as local migration or migration between regions within the country.

Surveillance within the realm of government and public policy pertains to the systematic process of monitoring and evaluating policy enactments by governmental agencies or other entities. This ensures adherence to policy goals, identifies deviations and directs necessary improvements. Furthermore, surveillance regarding foreigners is delineated as an effort executed by immigration authorities to monitor and regulate the movement of foreign nationals within Indonesian territory. This surveillance is pivotal to ensuring that foreign nationals entering and residing in Indonesia comply with prevailing laws and regulations (Aji et al., 2022).

The surveillance of foreign nationals is executed prior to, during, and within the territory of Indonesia. This surveillance entails the administrative identification, collection, and processing of data on foreign nationals within the immigration management information system, as well as field operations. Pre-entry surveillance into Indonesian territory is conducted through an integrated process when foreign nationals apply for a visa. Additionally, surveillance occurs as the foreign national enters Indonesian territory, from boarding transportation (airplane, ship, or land vehicle) to the immigration clearance process at the designated point of entry. Furthermore, continuous surveillance is exercised while the foreign national resides in Indonesia to ensure their

activities are beneficial and comply with prevailing regulations.

2.3 Geospatial Intelligence

Intelligence, as defined by Prunckun (2015), refers to a systematic process encompassing a rigorously structured and systematically organized sequence of steps or activities aimed at collecting, processing, analyzing, and distributing information. This procedural framework underpins decision-making across various domains, notably national security, law enforcement, and business. Each phase within this process is pivotal, ensuring that the gathered information is pertinent, precise, and dependable, thereby facilitating its application in formulating effective strategies and actions.

Saronto (2018) identifies three manifestations of intelligence within a nation: as an organization, as an activity, and as knowledge, described as follows:

- a. Intelligence as an organization refers to intelligence agencies that operate discreetly beyond public scrutiny.
- b. Intelligence as an activity encompasses both routine and special intelligence operations conducted covertly and within specific time constraints. These activities relate to three primary intelligence functions: investigation, security, and mobilization. Investigative efforts focus on gathering and compiling information into intelligence reports that underpin security and mobilization strategies, which include preventative and pre-emptive measures against threats.
- c. Intelligence as knowledge pertains to the specialized understanding derived from the analysis of accumulated information, forming intelligence products. These products serve policymakers or end users by predicting potential threats, informing strategic decisions, and underpinning effective national policy planning.

Immigration intelligence performs critical functions such as investigation, mobilization, and security, aligning with its role in law enforcement and national security. According to Prunckun's (2015) intelligence entity type, immigration intelligence is categorized under both national security intelligence and law enforcement intelligence within the broader framework of environmental typology and intelligence organizations. Strategically, immigration intelligence operates at the level of national security intelligence, where its primary role is to prevent and deter threats posed by the arrival and presence of foreign nationals. Additionally, as a law enforcement entity, immigration intelligence conducts operations to gather evidence for the prosecution of foreign nationals.

Intelligence can be systematically classified into human intelligence (HUMINT), signals intelligence (SIGINT), imagery intelligence (IMINT), measurement and signature intelligence (MASINT), open-source intelligence (OSINT), and geospatial intelligence (GEOINT). Each category operates with the objective of facilitating efforts, tasks, activities, and actions aimed at early detection and early warning. The primary purpose is to prevent, deter, and manage any threats that could jeopardize national interests and security, as stipulated in the State Intelligence Law.

The term "geospatial" refers to data related to geographic location, which includes any aspect that can be identified by its position on the earth's surface, including the location, size, and shape of objects on earth (Evangelidis et al., 2018). Geospatial technologies encompass a variety of

tools and techniques utilized to collect, analyze, and visualize geographic data. These technologies involve Geographic Information Systems (GIS), remote sensing, and Global Positioning Systems (GPS).

Remote sensing facilitates the observation and data collection from a distance through satellites or aircraft, whereas a Geographic Information System (GIS) is a computer-based system utilized for the management, analysis, and mapping of geographic data. Conversely, the Global Positioning System (GPS) furnishes precise location data via satellite signals. The integration of these technologies enables the collection and analysis of spatial data with exceptional accuracy and efficiency (Zande et al., 2008).

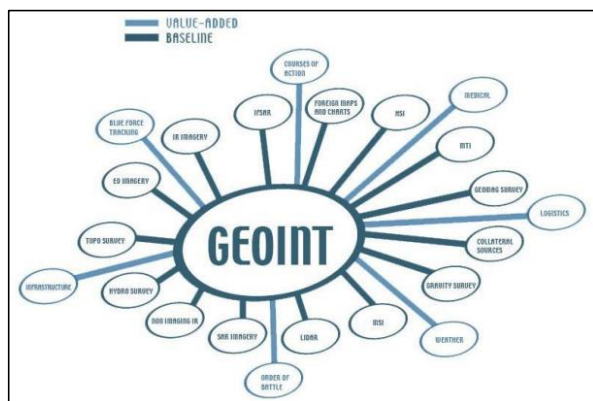


Fig. 1. Comprehensive Integration GEOINT of intelligence data and imagery (Sanchez, 2009)

Moreover, the data that has been collected undergoes thorough scrutiny before analysis (Mishra et al., 2020). Additionally, the data to be analyzed must possess a multidimensional aspect to ensure the production of a high-quality analysis (Zhihua et al., 2019). Geospatial intelligence encompasses the utilization, interpretation, and manipulation of data related to geographic locations for geospatial analysis (Gehlen et al., 2019; RA, 2024). Geospatial intelligence entails the analysis and visualization of geospatial data to evaluate human activities and physical features on Earth (Clarke, 2020). The data sourced from various reputable sources is subsequently analyzed to facilitate stakeholders in decision-making processes (Alaoui and Gahi, 2019). The advancement of artificial intelligence technology has also influenced geospatial intelligence, whereby the analysis of geospatial intelligence results now facilitates forecasting through the integration of Geospatial Artificial Intelligence (GeoAI) and Geocomputing (Song et al., 2023).

3. Research Method

3.1 PRISMA Method

This study employs a systematic literature review (SLR) to explore the role of geospatial intelligence (GeoINT) in immigration surveillance and its potential applications for enhancing national security in Indonesia. Adopting a qualitative research methodology, the study critically analyzes existing literature to identify trends, technologies, and challenges in using geospatial intelligence for immigration control. A comprehensive search strategy was employed using Scopus and Google Scholar, focusing on relevant publications indexed in these databases up until May 2024. Keywords such as "geospatial intelligence," "immigration surveillance," and "border security" guided the data collection process. After carefully reviewing and

filtering articles based on their relevance, quality, and alignment with the study's objectives, a total of 30 studies were selected for further analysis.

The review followed a structured selection process, ensuring that only peer-reviewed articles relevant to GeoINT's applications in immigration and border security were included. The selected articles were then analyzed to identify key types of geospatial technologies used, the challenges in their implementation, and their effectiveness in improving surveillance operations. A descriptive analysis method was applied to synthesize the findings, and the results were further elaborated in the discussion section of the study. The screening and selection process adhered to the PRISMA guidelines, ensuring the transparency and rigor of the review.

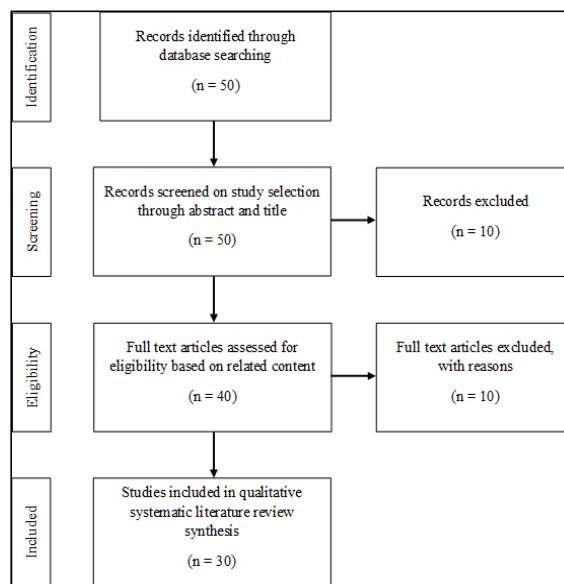


Fig. 2. Prisma Diagram Table

3.2 Research Data Collection

The Scopus and Google Scholar databases were utilized as the main data sources for this systematic literature review (SLR), focusing on the integration of geospatial intelligence (GeoINT) in immigration surveillance. These databases provide comprehensive coverage of academic articles, ensuring a rigorous selection process for the study. The inclusion criteria were as follows:

1. Search terms ("geospatial intelligence" OR "GeoINT") AND ("immigration surveillance" OR "border control") were employed to retrieve all relevant articles containing any of these keywords in the title, abstract, or author keywords. This approach ensures a wide coverage of studies related to the application of geospatial intelligence in immigration and border security.
2. Peer-reviewed journal articles were prioritized to guarantee the reliability and academic rigor of the sources.
3. The search was confined to articles indexed in Scopus and SINTA databases. SINTA 2 and SCOPUS were chosen due to their reputation for high-quality publications with a global reach.

Following these criteria, a total of 50 articles were initially retrieved. After applying filtering criteria for article type, publication year (2020-2024), language, and metadata completeness, 30 articles were selected for in-depth analysis (see Table 2).

Table 2. Search Query Result Table

Step	Filtering Criteria	Query on Journal
Initial search results	Search term ("geospatial intelligence" OR "GeoINT") AND ("immigration surveillance" OR "border control")	50
Year filter	LIMIT-TO ("2020-2024")	45
Source type filter	LIMIT-TO ("journal")	40
Metadata completeness filter	Manual filters applied, removing articles lacking sufficient metadata	35

4. Result and Discussions

4.1 Potential Application of Geospatial Intelligence in the Immigration Sector

Geospatial intelligence has been employed by various nations in the realm of immigration. The potential for leveraging open geospatial technology to support immigration intelligence and the surveillance of foreign nationals is significant. The integration of geospatial technology with other intelligence data collection methodologies is likely to yield a more nuanced and comprehensive output in immigration intelligence.



Fig. 3. Webgis Mapping the Number of Foreigners (Yunita et al., 2022)

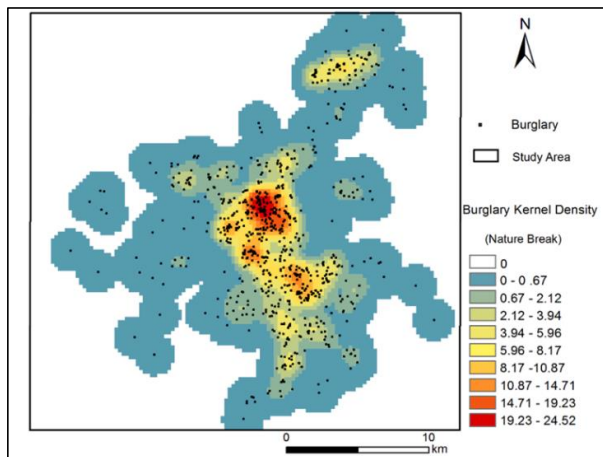


Fig. 4. Map of Geospatial Analysis Results (Cheng et al., 2022)

The address dataset within the Immigration System was developed by Yunita et al. (2022) to facilitate implementation testing, enabling visualization on a map. However, the resultant map should not be classified as the product of rigorous geospatial analysis; rather, it functions primarily as an infographic that employs color differentiation to represent the distribution of foreigners in various regions. Nevertheless, the integration of open-source mapping technologies in the domain of immigration-

related spatial applications signifies a noteworthy advancement.

Cheng et al. (2022); Hidayatillah et al. (2024) employed geospatial technology to assess theft risk in urban areas through a multiscale feature extraction and scale optimization framework. This framework delineates the neighborhood and optimizes spatial scales for neighborhood environmental variables. The study applied the multiscale feature extraction and scale optimization (MFESO) framework at Points of Interest (POIs), focusing on locations with varying levels of crowding, utilizing mobile phone user data to analyze the incidence of criminal events in the Xinjiang Uyghur region of China.

In his dissertation, Martin (2018) delineates the implications of geospatial intelligence (GEOINT) deployment at the United States-Mexico border. The methodology employed is a comparative case study focused on four states: California, Arizona, New Mexico, and Texas. The geospatial technologies incorporated include ground and aerial full-motion video sensors, infrared sensors, and synthetic aperture radar, which collectively contribute to the documentation of activities in regions characterized by elevated levels of illegal border crossings. GEOINT offers essential insights for border security professionals and strategists, enhances the capabilities for detecting and apprehending individuals attempting illegal border crossings, and contributes to the broader narrative surrounding the issue of illegal immigration along the U.S.-Mexico border.

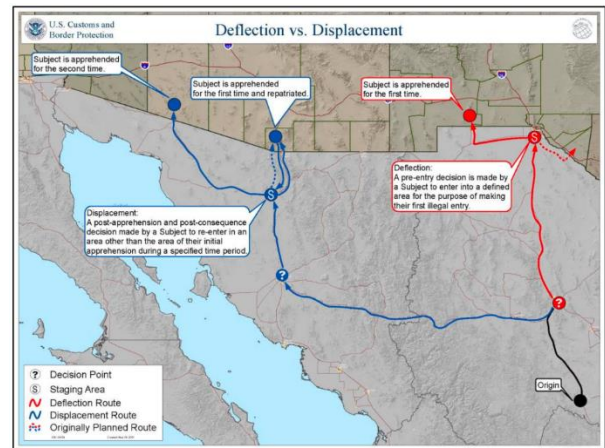


Fig. 5. Results of Geospatial Analysis of Human Smuggling Pathways on the US - Mexico Border (Martin, 2018)

In the same context of the United States-Mexico border, Walsh (2013) employed a case study analysis method to examine the utilization of geospatial technology by humanitarian activists in their efforts to contest United States-Mexico border security policies. The geospatial tools utilized encompass Geographic Information Systems (GIS), GPS-based navigation systems, and specialized software that enables the creation of digital maps, thereby facilitating safer crossings for migrants. These geospatial technologies serve dual purposes: they are not only employed for surveillance by governmental entities but are also adopted by activists to extend humanitarian assistance. This includes the strategic placement of water stations in arid regions and the provision of navigational aids for migrants, which consequently contribute to a reduction in border-related fatalities and challenge prevailing repressive narratives surrounding border security.

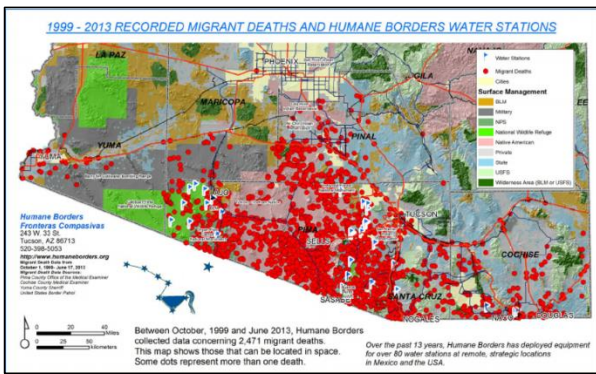


Fig. 6. Results of Geospatial Analysis of Migrant Deaths on the US-Mexico Border 1999-2013 (Walsh, 2018)

Nezami and Khoramshahi (2016) employed the Geographically Weighted Regression (GWR) methodology in their research. They utilized Geographic Information Systems (GIS) in conjunction with regression analysis to delineate the spatial distribution of drug smuggling-related crimes within South Khorasan Province, Iran. The analysis of crime data aimed to elucidate its spatial distribution and its correlation with various factors, including population density, proximity to urban centers, distance to the nearest police station, and the illiteracy rate. The findings indicated that crime distribution was non-random, conforming to a distinct spatial pattern characterized by crime hotspots situated at considerable distances from police stations. The resulting GWR model facilitates the prediction of fluctuations in crime distribution based on changes in these variables, thereby supporting effective planning and strategic decision-making in crime prevention efforts.

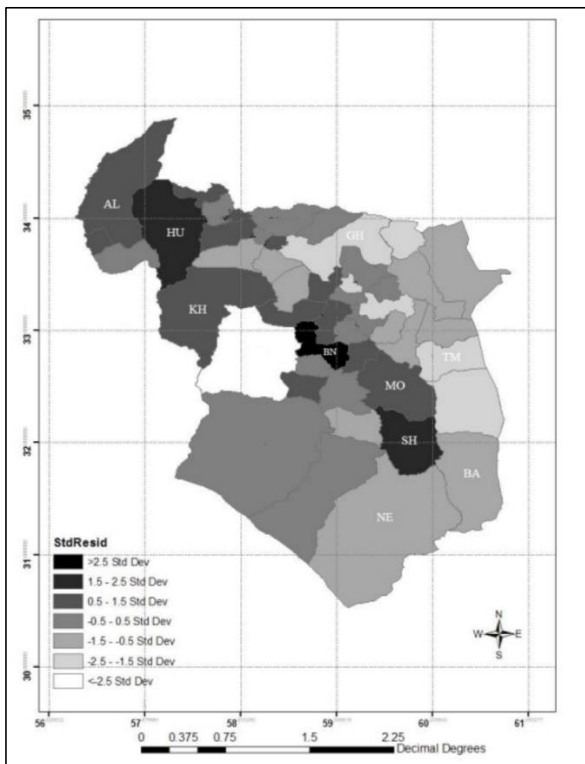


Fig. 7. GWR Model on Crime Data (Nezami and Khoramshahi, 2016)

Stefanidis et al. (2014) conducted a study employing social media alongside content analysis to enhance the development of geospatial intelligence. The methodologies

incorporated include Geographic Information Systems (GIS) and application programming interfaces (APIs) from social media platforms to gather geolocation data from tweets. This research illustrates that social media data can be analyzed to map social and cultural dynamics, identify social hotspots, and provide an in-depth understanding of social network structures and information dissemination in real-time. The findings highlight the significant potential of social media as a vital source of geospatial information for diverse security and social analysis applications.

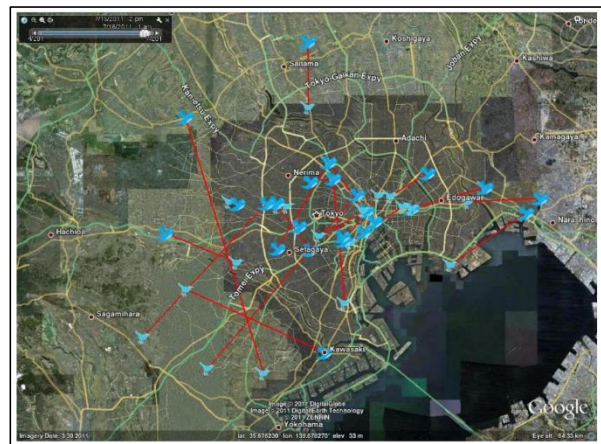


Fig. 8. Geolocation Pairs of Tokyo Maps in Tweets & Re-tweets of social media Tweeters After the Sendai Earthquake Incident (Stefanidis et al., 2014)

Moreover, the output of geospatial intelligence serves as a vital simulation tool in the execution of border surveillance operations. Latek et al. (2012) employed multi-agent simulation methodologies to evaluate border security dynamics between the United States and Mexico. This study integrated open-source data regarding the number of border security personnel alongside human smuggling organizations, in addition to the physical infrastructure and sensor networks located within the Arizona-Sonora border region. Geographic Information Systems (GIS) were utilized to effectively map the geographic landscape and illicit smuggling routes. The employed sensor instruments encompassed both fixed and mobile platforms. Findings from the research indicate that social simulation techniques can successfully identify critical smuggling routes, model strategic interactions between security personnel and smugglers, and facilitate the planning and optimization of border security operations, thereby enhancing both the efficiency and effectiveness of border security measures.

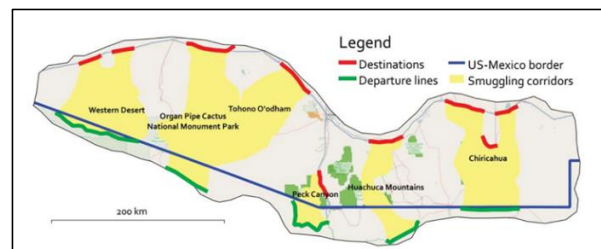


Fig. 9. Human Smuggling Corridors Forecast Map

Based on eight studies pertaining to the utilization of geospatial intelligence, it can be inferred that the potential application of integrating geospatial intelligence with immigration intelligence may enhance the surveillance of foreign individuals, as illustrated in the table below (Table 3).

Table 3. Utilization potential of Geospatial Intelligence in Immigration

No.	Author	Utilization Potential	Description
1	Yunita, et. al.	WebGis Mapping of Foreigners	As the initial user-interface of immigration geospatial intelligence
2	Cheng, et. al.,	Mapping the occurrence of violations committed by foreigners	Using immigration violation data variables and data on the locus of violation at the examination along with POI density and cellphone usage variables.
3	Martin Walsh	Forecasting human smuggling routes based on past smuggling data	Using data on the modus operandi of smuggling routes in the examination of human smuggling crimes, along with additional qualitative data variables from field surveillance and quantitative data from sensor instruments at the Indonesian border.
4	Nezami & Khoramshahi	Implementation of GWR Model for forecasting immigration violation events based on certain variables	Population variables, as well as the distances from urban centers and the nearest immigration offices, can serve as significant predictors for forecasting potential immigration violation events.
5	Stefandis, et al.,	Development of geospatial intelligence on immigration violation events that go viral on social media	The interaction observed on social media regarding an immigration violation event that attains viral status serves as a source for data collection intended for geospatial analysis.
6	Latek, et al.,	Simulating surveillance scenarios for foreigners using geospatial intelligence on points of interest.	Geospatial intelligence concerning points of interest, in conjunction with an analysis of personnel capabilities and surveillance patterns, is employed as a framework for enhanced and more efficient surveillance of foreign individuals.
7	Doran, N. M., Badareu, G., & Siminică, M. I.	Integrating Geospatial Intelligence and Digital Transformation for Advancing Environmental Sustainability in Emerging EU Economies	digitalization fosters improved integration of renewable energy sources, highlighting the strategic role of GIS&T in monitoring and optimizing sustainability initiatives.
8	Janowicz K, Gao S, McKenzie G, Hu Y, Bhaduri B	GeoAI: spatially explicit artificial intelligence techniques for geographic knowledge discovery and beyond	explores the use of GeoAI, focusing on AI techniques that incorporate spatial data to uncover geographical knowledge and how it can be applied in various disciplines beyond geography
9	Liu P, Biljecki F	A review of spatially-explicit GeoAI applications in Urban Geography	examines how spatially explicit GeoAI methods are applied in urban geography to analyze urban environments, including topics like land use, transportation, and urban planning
10	Chauhan LP, Shekhar S	GeoAI - Accelerating a virtuous cycle between AI and Geo	interconnection between AI and geospatial data, exploring how advancements in AI techniques can enhance geographic research and vice versa, creating a mutually beneficial cycle.
11	Boulos MN, Wilson JP	Geospatial techniques for monitoring and mitigating climate change and its effects on human health	how geospatial technologies can be used to track climate change and its impact on public health, aiming to provide solutions for mitigation and adaptation strategies.
12	Pierdicca R, Paolanti M	GeoAI: A review of artificial intelligence approaches for the interpretation of complex geomatics data	AI techniques tailored to the interpretation of geomatics data, focusing on the challenges and advancements in processing complex spatial datasets
13	Li W, Hsu CY	GeoAI for Large-Scale Image Analysis and Machine Vision: Recent Progress of Artificial Intelligence in Geography	the role of AI in large-scale image analysis and machine vision within the field of geography, focusing on recent developments and applications.
14	Song, Y., Kalacska, M., Gašparović, M., Yao, J., & Najibi, N.	Advances in geocomputation and geospatial artificial intelligence (GeoAI) for mapping	highlights recent advancements in geocomputation and GeoAI, emphasizing their use in improving mapping techniques and spatial analysis.
15	Martina, B., Monica, L.P., Glenn, V., & Danny, V.	The role of Spatial Data Infrastructures in the Digital Government Transformation of Public Administrations	how spatial data infrastructures (SDIs) support digital government transformation by improving the accessibility and use of geospatial data in public administration.
16	Padden, M.	The transformation of surveillance in the digitalisation discourse of the OECD: a brief genealogy	the concept of surveillance has evolved within the context of digitalization, particularly in OECD countries, and how it influences governance and policy.
17	Zhu, X., Ge, S., & Wang, N.	Digital transformation: A systematic literature review	digital transformation literature, examining its definitions, frameworks, and impacts across various industries and sectors.
18	Metcalfe, J., Ellul, C., Morley, J., & Stoter, J.E.	Characterizing the Role of Geospatial Science in Digital Twins	explores the contribution of geospatial science to the development and functioning of digital twins, virtual representations of real-world systems and environments.
19	Kolluru, V., Mungara, S., & Naidu, A.	Geospatial Intelligence Enhancement Using Advanced Data Science And Machine Learning: A Systematic Literature Review	how advanced data science and machine learning techniques are enhancing geospatial intelligence (GEOINT) applications, such as in defense, environmental monitoring, and disaster response.
20	Mahmood, G., Khakwani, M.S., Zafar, A., & Abbas, Z.	Impact of Digital Transformation and AI through Fostering Digital Leadership Excellence: A Focus on	examines how digital transformation and AI contribute to sustainable organizational performance by fostering digital leadership and innovation.

		Sustainable Organizational Performance	
21.	Yusfan, M.A., Supriyadi, A.A., Martha, S., Gultom, R.A., & Sakti, S.K.	Geospatial Intelligence (GEOINT) As A National Defense Strategy for Information Overload in Indonesia	focuses on how geospatial intelligence (GEOINT) can be leveraged as a national defense strategy to address information overload challenges in Indonesia.
22.	del Cerro Velázquez, F., & Morales Méndez, G	Systematic Review of the Development of Spatial Intelligence through Augmented Reality in STEM Knowledge Areas	how augmented reality (AR) is being used to enhance spatial intelligence in STEM (Science, Technology, Engineering, and Mathematics) education and research.
23.	Wang, S., Huang, X., et al.	Mapping the landscape and roadmap of geospatial artificial intelligence (GeoAI) in quantitative human geography: An extensive systematic review	how GeoAI is being applied in quantitative human geography, mapping the current landscape and future research directions.
24.	Wang, J., & Biljecki, F.	Unsupervised machine learning in urban studies: A systematic review of applications	review examines the application of unsupervised machine learning techniques in urban studies, focusing on how these methods are used to analyze complex urban data.
25.	Obringer, R., White, D.D.	Leveraging Unsupervised Learning to Develop a Typology of Residential Water Users' Attitudes Towards Conservation	how unsupervised machine learning can classify and understand different attitudes of residential water users towards conservation efforts.
26.	Luo, Y., Yan, J., McClure, S.C. et al.	Socioeconomic and environmental factors of poverty in China using geographically weighted random forest regression model	uses a geographically weighted random forest regression model to analyze the socioeconomic and environmental factors contributing to poverty in China.
27.	Agonafir, C., et al.	A machine learning approach to evaluate the spatial variability of New York City's 311 street flooding complaints	applies machine learning to assess the spatial variability of flooding complaints in New York City, aiming to identify patterns and inform better urban planning.
28.	Thakur, N., Virk, A., & Nanda, V.	Geospatial Intelligence: A Comprehensive Review of Emerging Trends and Applications in 2024	emerging trends in geospatial intelligence (GEOINT) and its applications, focusing on the latest developments and future directions.
29.	Hassan, W., Qasim, M., Alshameri, B., Shahzad, A., Khalid, M.H., & Qamar, S.U.	Geospatial intelligence in geotechnical engineering: a comprehensive investigation into SPT-N, soil types, and undrained shear strength for enhanced site characterization	the application of geospatial intelligence in geotechnical engineering to improve site characterization. By integrating SPT-N values, soil types, and undrained shear strength data, it aims to develop more accurate models for assessing soil conditions, critical for designing safe and stable infrastructure.
30.	Mansourihanis, O., Maghsoodi Tilaki, M.J., et al.	Integrating geospatial intelligence and spatio-temporal modeling for monitoring tourism-related carbon emissions in the United States	combines geospatial intelligence and spatio-temporal modeling to monitor carbon emissions from tourism in the U.S. It uses geospatial data to track tourist locations and movements, alongside temporal modeling to predict long-term environmental impacts, helping to design policies for reducing the carbon footprint of tourism.

4.2 Diffusion of Geospatial Intelligence in the Immigration Sector

The integration of geospatial intelligence (GEOINT) into immigration surveillance represents a pivotal transformation in managing border security and monitoring the mobility of foreign nationals. GEOINT incorporates Geographic Information Systems (GIS), satellite imagery, and real-time data analytics, offering a spatially enriched perspective of cross-border human movements. In the context of Indonesia—an archipelagic country with over 17,000 islands—traditional surveillance methods are often challenged by geographical fragmentation and porous entry points. GEOINT provides a strategic technological solution to these complexities, enabling enhanced monitoring, predictive threat detection, and resource optimization.

According to Rogers' Diffusion of Innovation theory, the spread of technological innovations follows five adopter categories: innovators, early adopters, early majority, late majority, and laggards. In Indonesia, innovators in GEOINT deployment may include technologically advanced state agencies like BNPB and BIN, which already possess the infrastructure and experience in handling satellite-based intelligence. These entities could serve as pilot environments for integrating GEOINT into immigration surveillance, offering initial data on feasibility and impact.

Early adopters are expected to include key immigration checkpoints such as Ngurah Rai Airport and Soekarno-Hatta International Airport, which manage the bulk of foreign national entries. These sites face elevated risks related to overstays and irregular migration, making them ideal for early experimentation with GEOINT. Once proof of concept is demonstrated, the early majority—such as regional immigration offices and medium-scale seaports like Batam Center—could follow suit. Conversely, offices with fewer foreign arrivals may join the late majority due to lower urgency. Laggards, typically remote posts with limited resources, would adopt GEOINT last, likely compelled by national directives rather than voluntary uptake.

To draw more contextually grounded conclusions, a comparative analysis with the U.S.-Mexico border context could be insightful. The U.S. experience reveals how GEOINT technologies assist in detecting illegal crossings, mapping migration corridors, and responding rapidly to security breaches. Although Indonesia's terrain and threat profile differ, lessons from the U.S. context—such as the use of AI-enhanced imagery and drone surveillance—can inform a tailored Indonesian strategy.

Applying Rogers' stages of innovation adoption—knowledge, persuasion, decision, implementation, and confirmation—offers a structured lens to evaluate the diffusion process in Indonesia.

1. **Knowledge Stage:** This stage emphasizes raising awareness among immigration stakeholders about the capabilities of GEOINT. Workshops, pilot trials, and collaboration with academia and the tech industry are essential to build foundational knowledge, particularly in remote border regions vulnerable to undocumented crossings and illegal activities.
2. **Persuasion Stage:** Pilot sites such as Jakarta and Bali should be used to showcase GEOINT's impact on real-time tracking, detection of visa overstays, and mitigation of trafficking. Demonstrable results will help shape favorable opinions. To address resistance, clear communication on cost-efficiency, ease of use, and interoperability with existing systems must be part of the persuasion process.
3. **Decision Stage:** Here, the focus shifts to formal policy-making and funding. A multisectoral approach involving the Directorate General of Immigration, Ministry of Law and Human Rights, and cybersecurity units is vital. Policies should focus on data governance, cross-agency coordination, and budget allocation.
4. **Implementation Stage:** GEOINT infrastructure should first be installed at high-traffic points, integrating satellite data feeds, UAV imagery, and smart-mapping systems. Parallel to this, intensive training programs must be conducted to upskill officers in interpreting spatial data, ensuring the system's operational success.
5. **Confirmation Stage:** The success of early deployments will lead to wider adoption. Regular evaluations and publication of impact metrics—such as improved interdiction rates or decreased overstays—will reaffirm GEOINT's value. This stage should also include policy refinement and the expansion of the system nationwide.

Key benefits of GEOINT for Indonesian immigration include improved response time to border threats, accurate profiling of movement patterns, and more effective deployment of human resources based on spatial intelligence. These benefits are particularly crucial given the archipelagic geography and the prevalence of unauthorized maritime entries.

However, several risks must also be acknowledged. Data privacy, system misuse, technological overdependence, and public mistrust are potential challenges. The adoption process must therefore be accompanied by regulatory frameworks ensuring accountability, data protection, and ethical usage.

To further strengthen the foundation for GEOINT adoption, future research should explore: (a) Case studies on successful GEOINT deployments in countries with similar geographical characteristics, such as the Philippines, (b) Impact assessments of GEOINT on community trust and local cooperation, (c) Design and evaluation of training modules for GEOINT literacy among immigration personnel.

4.3 Discussion

The implementation of Geospatial Intelligence (GEOINT) in Indonesia's immigration system represents a strategic step in strengthening national security and cross-border management. As an archipelagic country with thousands of scattered entry and exit points, the integration of GEOINT can provide concrete benefits such as accelerating responses to security threats, improving the efficiency of resource allocation in surveillance operations,

and mapping migrant movement patterns more accurately. This technology, if applied optimally, is able to support spatial data-based decision-making, especially in border areas such as Nunukan, Entikong, and other areas prone to illegal crossings. Within the framework of Diffusion of Innovation Theory (Rogers, 2003), the stages of GEOINT adoption—from knowledge, persuasion, decision, implementation, to confirmation—describe how this technology is beginning to be recognized and adopted by immigration institutions, although it is generally still in its early stages. Some institutions such as BIG, BNPB, and large airport immigration units can be categorized as innovators and early adopters because they have accessed and utilized spatial data, while most immigration offices in the region are still at the early majority stage waiting for policy certainty and technical readiness.

However, the implementation of GEOINT is not without challenges. Privacy and data protection issues emerge as one of the main concerns, especially if monitoring is carried out without clear legal restrictions. The potential for data misuse and inequality in human resource capacity are serious obstacles that must be anticipated. On the other hand, this kind of surveillance technology can also trigger social resistance in local communities if it is not accompanied by a participatory approach and policy transparency. Therefore, regulations that ensure accountability, independent system audits, and ethics-based training for field officers are needed so that the use of GEOINT remains within the corridor of human rights and public interest. In addition, in order for its application to be more effective, further research is needed that evaluates the effectiveness of various GEOINT technologies in the field, examines best practices from other countries such as Australia and the European Union, and explores public perceptions of surveillance technologies in their environments. Research also needs to be directed towards the development of training programs that are appropriate to the needs of immigration institutions and understand how the integration of GEOINT will affect the relationship between immigration authorities and local communities, particularly in building trust and cooperation in supervision. With this comprehensive approach, the implementation of GEOINT in Indonesia's immigration sector will not only strengthen security, but also be socially and ethically sustainable.

5. Conclusion

The integration of GEOINT within Indonesia's immigration framework represents a significant advancement, enhancing the nation's capacity to monitor and regulate the influx of foreign nationals. Through the integration of advanced geospatial technologies, immigration authorities are poised to systematically track and analyze movement patterns, identify potential security threats, and optimize resource allocation. This digital transformation aligns with Indonesia's immigration selective policy to promote economic development through the facilitation of foreign national entry while simultaneously upholding national security. The incorporation of GEOINT into immigration surveillance not only strengthens early detection capabilities but also correlates with the broader initiative to modernize Indonesia's public sector through innovative digital practices.

The diffusion of geospatial intelligence necessitates meticulous navigation through the stages of adoption, ranging from awareness-building to full implementation.

Initial successes in major immigration checkpoints, such as Ngurah Rai and Soekarno-Hatta Airports, will serve as catalysts for broader adoption, while sustained governmental support, investment in infrastructure, and comprehensive training programs are essential for addressing potential challenges. By adhering to the principles of the diffusion of innovation theory, Indonesia can ensure that geospatial intelligence is embraced as a widely accepted and effective instrument for safeguarding its borders and managing the complex dynamics of international migration.

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References

- Adani, P.S., Astutiningsih, S., Wahyono, S., Sunaryo, S., 2022. Implementasi kebijakan Visa on Arrival (VoA) dalam meningkatkan kunjungan wisatawan mancanegara di Provinsi Bali. *JPLAN*. <https://doi.org/10.32834/jplan.v4i2.530>
- Aji, M.R.S., Doroteusgaza, R.E., Pakpahan, F.W., 2022. Pelaksanaan Pengawasan Keimigrasian Efektif terhadap Orang Asing Pemegang Bebas VISA Kunjungan di Wilayah Indonesia. *jiip* 5, 5585–5592. <https://doi.org/10.54371/jiip.v5i12.1193>
- Alaoui, I.E., Gahi, Y., 2019. The Impact of Big Data Quality on Sentiment Analysis Approaches. *Procedia Computer Science* 160, 803–810. <https://doi.org/10.1016/j.procs.2019.11.007>
- Burnett, A., 2002. Globalization, migration and health*. *Medicine, Conflict and Survival* 18, 34–43. <https://doi.org/10.1080/13623690208409604>
- Cheng, J., Zhang, X., Huang, J., 2022. Optimizing the spatial scale for neighborhood environment characteristics using fine-grained data. *International Journal of Applied Earth Observation and Geoinformation* 106, 102659. <https://doi.org/10.1016/j.jag.2021.102659>
- Clarke, K.C., 2020. Geospatial Intelligence, in: *International Encyclopedia of Human Geography*. Elsevier, pp. 127–130. <https://doi.org/10.1016/B978-0-08-102295-5.10550-5>
- Detik.com, 2024. Until May 2024, Immigration Takes Administrative Action on 1,761 Foreign Nationals.
- Evangelidis, K., Papadopoulos, T., Papatheodorou, K., Mastorokostas, P., Hilas, C., 2018. 3D geospatial visualizations: Animation and motion effects on spatial objects. *Computers & Geosciences* 111, 200–212. <https://doi.org/10.1016/j.cageo.2017.11.007>
- Frambach, R.T., Schillewaert, N., 2002. Organizational innovation adoption: a multi-level framework of determinants and opportunities for future research. *Journal of Business Research* 55, 163–176. [https://doi.org/10.1016/S0148-2963\(00\)00152-1](https://doi.org/10.1016/S0148-2963(00)00152-1)
- Gehlen, M., Nicola, M.R.C., Costa, E.R.D., Cabral, V.K., De Quadros, E.L.L., Chaves, C.O., Lahm, R.A., Nicoletta, A.D.R., Rossetti, M.L.R., Silva, D.R., 2019. Geospatial intelligence and health analytics: Its application and utility in a city with high tuberculosis incidence in Brazil. *Journal of Infection and Public Health* 12, 681–689. <https://doi.org/10.1016/j.jiph.2019.03.012>
- Hidayatillah, A. S., Nurcahyo, T. A., Muliawan, J. B. P., & Endarsih, A. E. (2024). Identifying Dominant Structural Pattern of Semarang City Using Digital Elevation Model and Landsat 8-OLI Imagery. *Journal of Geoscience, Engineering, Environment, and Technology*, 9(1), 28-37.
- Janelle, D.G., Beuthe, M., 1997. Globalization and research issues in transportation. *Journal of Transport Geography* 5, 199–206. [https://doi.org/10.1016/S0966-6923\(97\)00017-3](https://doi.org/10.1016/S0966-6923(97)00017-3)
- Jannah, M., Pamumpuni, A., & Sadisun, I. A. (2024). Segmentation of the Active Fault on the Cirebon-Semarang Segments as Revealed by DEM-Derived Geomorphic Indices. *Journal of Geoscience, Engineering, Environment, and Technology*, 9(04), 385-399.
- Jati, N.M.P.K., Arthanaya, I.W., Utama, I.N., 2021. Supervision of Foreigners on the Implementation of Visa-Free Visits at the Ngurah Rai Special Class 1 Immigration Office. *JPH* 2, 93–98. <https://doi.org/10.22225/jph.2.1.3052.93-98>
- Jetten, J., 2019. The wealth paradox: Prosperity and opposition to immigration. *Euro J Social Psych* 49, 1097–1113. <https://doi.org/10.1002/ejsp.2552>
- Khorniawan, W. B., Jayanti, A. G. R., & Caesario, D. (2024). Quantitative Analysis of Thin Section using Frequency Measurement (Point Counting), a Case Study on Limestone of The Rajamandala Formation, Cikamuning, West Java, Indonesia. *Journal of Geoscience, Engineering, Environment, and Technology*, 9(3), 245-252.
- Latek, M.M., Rizi, S.M.M., Crooks, A., Fraser, M., 2012. Social Simulations for Border Security, in: 2012 European Intelligence and Security Informatics Conference. Presented at the 2012 European Intelligence and Security Informatics Conference (EISIC), IEEE, Odense, Denmark, pp. 340–345. <https://doi.org/10.1109/EISIC.2012.50>
- Luo, X., Chung, C.-N., Sobczak, M., 2009. How do corporate governance model differences affect foreign direct investment in emerging economies? *J Int Bus Stud* 40, 444–467. <https://doi.org/10.1057/jibs.2008.66>
- Marini, M., Chokani, N., Abhari, R.S., 2019. Agent-Based Model Analysis of Impact of Immigration on Switzerland's Social Security. *Int. Migration & Integration* 20, 787–808. <https://doi.org/10.1007/s12134-018-0631-8>
- Martin, H., 2018. The Effects of Geospatial-Intelligence on United States-Mexico Border Security (Dissertations). The University of Southern Mississippi.
- McWhorter, J., Hernandez, S.R., Sen, B.P., Patrician, P., Luquire, R., 2013. Organizational Predictors of Early Adopters of Innovation. *AMPROC 2013*, 16636. <https://doi.org/10.5465/ambpp.2013.16636abstract>
- Ministry of Communication and Information of the Republic of Indonesia, n.d. Arrival and Departure Crossings for Indonesian and Foreign Citizens.
- Mishra, P.K., Rai, A., Rai, S.C., 2020. Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India. *The Egyptian Journal of Remote Sensing and Space Science* 23, 133–143. <https://doi.org/10.1016/j.ejrs.2019.02.001>
- Money, J., 2021. Globalization, international mobility and the liberal international order. *International Affairs*

- 97, 1559–1577. <https://doi.org/10.1093/ia/iiab118>
Montevideo Convention Montevideo Convention.pdf, n.d.
- Nezami, S., Khoramshahi, E., 2016. Spatial Modeling of Crime by Using of GWR Method, in: 2016 Baltic Geodetic Congress (BGC Geomatics). Presented at the 2016 Baltic Geodetic Congress (BGC Geomatics), IEEE, Gdansk, Poland, pp. 222–227. <https://doi.org/10.1109/BGC.Geomatics.2016.47>
- Nijkamp, P., 2003. Globalization, international transport and the global environment: A research and policy challenge. *Transportation Planning and Technology* 26, 1–8. <https://doi.org/10.1080/03081060309912>
- Oser, C.B., Roman, P.M., 2008. A categorical typology of naltrexone-adopting private substance abuse treatment centers. *Journal of Substance Abuse Treatment* 34, 433–442. <https://doi.org/10.1016/j.jsat.2007.08.003>
- Philpott, D., 2020. Sovereignty, in: Zalta, E.N. (Ed.), *The Stanford Encyclopedia of Philosophy*, Fall 2020. Metaphysics Research Lab, Stanford University.
- Prunckun, H., 2015. *Scientific Methods of Inquiry for Intelligence Analysis*, 2nd ed. Rowman & Littlefield, London.
- RA, T. L. (2024). Spatial and Seasonal Variation of Doline Water Hydrochemistry in West Gunungsewu Karst Area, Yogyakarta Special Region, Indonesia. *Journal of Geoscience, Engineering, Environment, and Technology*, 9(2), 195-204.
- Richmond, A.H., 2002. Globalization: implications for immigrants and refugees. *Ethnic and Racial Studies* 25, 707–727. <https://doi.org/10.1080/0141987022000000231>
- Rodrigue, J.-P., 1999. Globalization and the synchronization of transport terminals. *Journal of Transport Geography* 7, 255–261. [https://doi.org/10.1016/S0966-6923\(99\)00018-6](https://doi.org/10.1016/S0966-6923(99)00018-6)
- Rogers, E.M., 2003. *Diffusion of Innovations*. Free Press, New York.
- Romzah, M.I., 2023. Long Journey by VOA (Visa on Arrival). KSS. <https://doi.org/10.18502/kss.v8i11.13564>
- Sanchez, A., 2009. Leveraging Geospatial Intelligence (GEOINT) in Mission Command.
- Saronto, Y.W., 2018. *Intelijen: Teori intelijen dan pembangunan jaringan*. Andi, Yogyakarta.
- Sergeevna, P.E., Jacob, V., 2022. Globalization and migration processes. *Chronos* 7, 93–96.
- Shamir, R., 2005. Without Borders? Notes on Globalization as a Mobility Regime. *Sociological Theory* 23, 197–217. <https://doi.org/10.1111/j.0735-2751.2005.00250.x>
- Song, Y., Kalacska, M., Gašparović, M., Yao, J., Najibi, N., 2023. Advances in geocomputation and geospatial artificial intelligence (GeoAI) for mapping. *International Journal of Applied Earth Observation and Geoinformation* 120, 103300.
- Stefanidis, A., Crooks, A., Radzikowski, J., Croitoru, A., Rice, M., 2014. Social media and the emergence of open source geospatial intelligence. *Human Geography: Socio-Cultural Dynamics and Global Security* 1, 109–123.
- Suciptawati, N.L.P., Dharmawan, K., Sudiarta, I.N., 2015. Modeling of Foreign Tourist Visits to Bali Province, in: *National Seminar on Mathematics and Mathematics Education UNY*. pp. 109–116.
- Sudini, L.P., 2008. Peranan Visa On Arrival (VoA) Bagi Orang Asing Yang Datang Ke Indonesia. *JHP* 38, 335. <https://doi.org/10.21143/jhp.vol38.no3.175>
- Utami, P.N., Rahmanto, T.Y., 2020. Peran Imigrasi Terhadap Fenomena Sosial Orang Asing Yang Bekerja Tidak Sesuai Aturan Di Indonesia. *Jurnal Ketenagakerjaan* 15, 42–56.
- Valente, T.W., 1996. Social network thresholds in the diffusion of innovations. *Social Networks* 18, 69–89. [https://doi.org/10.1016/0378-8733\(95\)00256-1](https://doi.org/10.1016/0378-8733(95)00256-1)
- Vaziri, M., Rezaee, A., 2008. Transportation Development and Globalization Trends: A Comparative Global Assessment, in: *Transportation and Development Innovative Best Practices 2008*. Presented at the First International Symposium on Transportation and Development Innovative Best Practices, American Society of Civil Engineers, Beijing, China, pp. 8–14. [https://doi.org/10.1061/40961\(319\)2](https://doi.org/10.1061/40961(319)2)
- Walsh, J., 2013. Remapping the Border: Geospatial Technologies and Border Activism. *Environ Plan D* 31, 969–987. <https://doi.org/10.1068/d18112>
- Xu, Q., 2007. Globalization, immigration and the welfare state: A cross-national comparison. *J. Soc. & Soc. Welfare* 34, 87.
- Yunita, R., Samsudin, S., Putri, R.A., 2022. Sistem Informasi Geografis Pemetaan Warga Negara Asing. *rabit* 7, 85–89. <https://doi.org/10.36341/rabit.v7i1.2188>
- Zande, D.V.D., Jonckheere, I., Stuckens, J., Verstraeten, W., Coppin, P., 2008. Impact of the sampling design on the quality of ground-based LiDAR datasets.
- Zhihua, L., Gong, Y., Holmes, M., Pan, X., Xu, Y., Zou, X., Fernandes, A.R., 2019. Geospatial visualisation of food contaminant distributions: Polychlorinated naphthalenes (PCNs), potentially toxic elements (PTEs) and aflatoxins. *Chemosphere* 230, 559–566. <https://doi.org/10.1016/j.chemosphere.2019.05.080>
- Zhou, Y., 2008. Voluntary adopters versus forced adopters: integrating the diffusion of innovation theory and the technology acceptance model to study intra-organizational adoption. *New Media & Society* 10, 475–496. <https://doi.org/10.1177/1461444807085382>



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