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Geospatial Mapping and Predictive Analysis for Drug Trafficking Intervention in Eastern Indonesia

Ismail[1], Felecia[2], Anisa Kurniatul Azizah[3], Diana Rahmawati[4]
[1] Universitas Bhayangkara Surabaya and ismail@ubhara.ac.id
[2] Universitas Kristen Petra and felecia@ukp.ac.id
[3] Universitas Bhayangkara Surabaya and anisa@ubhara.ac.id
[4] Universitas Bhayangkara Surabaya and dianarahma90@gmail.com

ABSTRACT

This study explores the application of geospatial mapping and predictive analysis in efforts to combat drug trafficking in Eastern Indonesia—a region characterized by complex geography and limited surveillance infrastructure. Using a qualitative approach, data were collected through in-depth interviews with three key informants: a regional police officer, a representative of the National Narcotics Agency (BNN), and a local community leader. The results reveal four central themes: the current state of drug trafficking in the region, the potential and underutilization of geospatial tools, the lack of predictive analytics at the regional level, and significant challenges such as limited infrastructure, lack of trained personnel, and poor inter-agency coordination. While the use of geospatial and predictive technologies remains nascent, stakeholders express optimism about their potential. The study highlights the need for context-specific strategies, local capacity-building, and multi-stakeholder collaboration to enhance data-driven interventions in narcotics control.

Keywords: *Geospatial Mapping, Predictive Analysis, Drug Trafficking, Eastern Indonesia.*

1. INTRODUCTION

In criminological studies, drug abuse offenses can be classified as victimless crimes. This classification refers to the nature of the crime, in which two parties engage in a prohibited transaction or relationship, yet neither perceives themselves as suffering harm from the other. Drug users are, in fact, victims of drug-related offenses themselves, but they do not see themselves as such because they intentionally use drugs whether due to peer influence, persuasion, or mere curiosity [1], [2].

Drug trafficking remains a persistent and complex challenge in Indonesia, particularly in its eastern regions, where geographical, socio-economic, and infrastructural factors create significant vulnerabilities. The proliferation of drug distribution networks has not only threatened national security but also posed serious risks to public health, social order, and economic stability. Eastern Indonesia, characterized by its vast archipelagic terrain, porous borders, and limited surveillance infrastructure, has increasingly become a target for transnational drug trafficking syndicates. Despite various enforcement efforts, the dynamic and covert nature of drug trafficking networks continues to outpace conventional control strategies. Indonesia's vast maritime borders make surveillance and enforcement difficult, allowing traffickers to exploit these gaps [1], while the archipelagic terrain complicates law enforcement operations as drug routes often traverse multiple islands [2].

Socio-economic issues further exacerbate the situation, with high levels of poverty and unemployment in eastern Indonesia contributing to the vulnerability of communities to drug trafficking [3], and areas like Sidenreng Rappang shifting from agricultural hubs to centers of drug production—indicating a socio-economic transformation driven by illicit activity [4]. Although Indonesia has ratified international conventions such as the 1961 Single Convention on Narcotic Drugs, implementation remains hindered by limited resources and weak inter-agency coordination

[5]. To counter these evolving threats effectively, enhanced international cooperation and the development of community-based preventive measures are essential [1].

In recent years, the integration of technology-based solutions—particularly geospatial mapping and predictive analysis—has emerged as a promising approach to enhance drug control efforts by strengthening data-driven decision-making, optimizing resource allocation, and enabling early detection of illicit activities. Geospatial mapping allows authorities to visualize spatial patterns of drug-related incidents and identify trafficking hotspots, as seen in Northern Thailand where specific districts were flagged based on their spatial relationship to drug smuggling incidents [6]. Geographic Information Systems (GIS) support the collection, organization, and analysis of such data, revealing substance abuse patterns and inter-regional connections across different geographic scales [7].

Meanwhile, predictive analysis tools, such as the Seasonal Trend decomposition based on Loess (STL) method, provide insights into future trafficking trends by analyzing historical data and contextual indicators [8]. This enables authorities to anticipate potential hotspots and allocate law enforcement resources more effectively, thereby enhancing proactive intervention and community policing efforts [6], [8]. Combined, these technological tools offer a targeted and forward-looking framework that is especially valuable for addressing drug-related threats in high-risk and hard-to-reach areas.

However, the application of these technologies in the context of Eastern Indonesia is still in its nascent stage. Challenges such as limited technological infrastructure, lack of skilled personnel, and insufficient inter-agency collaboration hinder the effective use of geospatial and predictive tools in anti-narcotics operations. Moreover, understanding the local context—such as community dynamics, cultural nuances, and the specific logistical routes used by traffickers—is crucial for designing effective intervention strategies.

Research Objective

This study aims to explore the potential of geospatial mapping and predictive analysis as strategic instruments for drug trafficking intervention in Eastern Indonesia. The study seeks to answer the following research questions:

1. How can geospatial mapping support drug trafficking interventions in Eastern Indonesia?
2. What role does predictive analysis play in anticipating and disrupting drug trafficking patterns?
3. What are the perceived challenges and opportunities in implementing these technologies at the regional level?

2. LITERATURE REVIEW

2.1 Drug Trafficking in Indonesia

Drug trafficking poses a significant threat to Indonesia's national resilience, particularly in Eastern Indonesia, where geographical and enforcement challenges facilitate the operations of trafficking networks. The region's strategic location—close to drug-producing countries such as the Philippines and Papua New Guinea—makes it a key transit hub for narcotics [1]. Compounded by vast maritime borders and rugged

terrain, Eastern Indonesia faces serious limitations in surveillance and enforcement capabilities [1], [9]. Additionally, the high number of drug users in areas like Batam City contributes to a steady and profitable market for traffickers [9]. Local intermediaries further complicate the situation by facilitating drug distribution and integrating trafficking activities within local communities, thereby hampering law enforcement efforts [3], [9]. Enforcement agencies also face significant technological gaps, particularly the absence of sophisticated detection tools at border checkpoints, which restricts interception efforts [9], [10]. Moreover, although Indonesia's legal framework on narcotics is relatively comprehensive, its implementation often lacks the deterrent power required to disrupt organized crime effectively [11].

2.2 Geospatial Mapping in Crime Prevention

Geospatial mapping, particularly through Geographic Information Systems (GIS), plays a crucial role in crime prevention by enabling law enforcement to visualize and analyze spatial data effectively, aiding in the identification of crime hotspots, understanding offender movement, and optimizing resource allocation. The integration of spatial analysis techniques enhances decision-making processes, leading to more effective policing strategies, such as hotspot identification through data clustering to facilitate targeted interventions [12], and efficient resource allocation by directing patrols to high-risk areas [13]. GIS also supports geographical investigative analysis, helping profile offenders based on spatial behavior patterns [13]. Furthermore, the clear visual representation of crime data aids command-level officers in making informed decisions [14], while spatial analysis of ecological and community factors enables the development of tailored crime reduction strategies [12], [14].

2.3 Predictive Analysis in Law Enforcement

Predictive analysis in law enforcement employs statistical models and algorithms to forecast criminal activity, enhancing proactive policing strategies by utilizing historical data to identify patterns and anticipate where and when crimes may occur, as well as potential offenders. This approach enables a shift from reactive to proactive methods, focusing on crime prevention rather than response [15], and strengthens techniques such as community-oriented and intelligence-led policing through targeted interventions [15]. The integration of machine learning algorithms, including decision trees and random forests, further refines this process by analyzing large datasets to detect crime trends and patterns [16], [17], allowing predictions based on factors like time, location, and demographics to improve forecasting accuracy [18]. However, the use of predictive models also introduces ethical concerns related to transparency and fairness, requiring careful and responsible application in law enforcement contexts [16].

2.4 Conceptual Framework

This study is grounded in the theoretical integration of technology-driven policing and community-based intelligence. Geospatial mapping and predictive analysis are conceptualized as technological enablers that enhance situational awareness, risk assessment, and operational decision-making in drug control efforts. The framework assumes that effective intervention strategies in drug trafficking require not only technological infrastructure but also local insights, institutional collaboration, and

policy support. The research draws on qualitative input from key stakeholders to explore how these tools are perceived, applied, and adapted in the regional context of Eastern Indonesia.

3. METHODS

3.1 Research Design, Informants and Sampling

This study uses a qualitative research design to explore the role and potential of geospatial mapping and predictive analysis in drug trafficking intervention in Eastern Indonesia. This approach allows for in-depth insights from stakeholders directly involved in anti-drug operations. The research was conducted in provinces identified as vulnerable to drug trafficking, including border and coastal areas. Three key informants were purposively selected: a senior regional police officer, an official from the provincial National Narcotics Agency (BNN), and a local community leader actively engaged in grassroots anti-drug efforts.

3.2 Data Collection Techniques and Data Analysis

Data were collected through semi-structured in-depth interviews, focusing on anti-drug strategies, perceptions of geospatial tools, use of predictive analysis, and institutional or technical barriers. Each interview lasted 60–90 minutes and was conducted either in person or via secure virtual platforms. Thematic analysis was applied following [19] framework, involving transcription, repeated reading, coding, theme development, and interpretation. NVivo software supported data organization and ensured consistency in the coding process.

4. RESULTS AND DISCUSSION

4.1 The Current State of Drug Trafficking in Eastern Indonesia

All informants agreed that drug trafficking in Eastern Indonesia has grown more sophisticated, leveraging geographic vulnerabilities and weak surveillance systems. *"Our maritime areas are vast, with many small ports that go unmonitored. These are used by drug networks to move freely, including shipments from abroad via sea routes,"* (Informant 1, Regional Police Officer). The BNN representative highlighted the shortage of personnel and technological infrastructure in the field. *"We lack enough officers and monitoring equipment in remote areas. Often, drug circulation happens before we even receive any intelligence,"* (Informant 2, Regional BNN Official).

The community leader expressed concern over rising drug abuse among young people in remote villages. *"Young people in the villages are getting involved more and more. It's spreading because there are no awareness programs and no consistent police presence,"* (Informant 3, Community Leader). These findings reflect national reports that Eastern Indonesia is becoming a strategic zone for drug transit due to its geography, limited surveillance, and weak inter-agency coordination.

4.2 Utilization and Potential of Geospatial Mapping

Each informant recognized the potential of geospatial mapping for drug intervention, although its practical application remains limited. Informant 2, a Regional BNN Official, noted, *"We have basic maps showing hotspot areas, but we don't have the tools to update or analyze them in real-time. GIS training and resources are mostly centered in Jakarta."* Similarly, Informant 1, a Regional Police Officer, highlighted the tactical advantages of geospatial tools, stating, *"If we could visualize where drug shipments are most likely to pass, especially along coastal entry points, we could plan better patrols."* These insights suggest that while geospatial data is valued, local institutions currently lack the necessary tools and training for effective implementation.

The community leader offered a different perspective, viewing geospatial mapping as a tool for public education and community awareness. *"Maps could help us inform villagers which areas are dangerous. People would be more alert if they could see what's happening around them,"* said Informant 3. This reinforces academic literature advocating for spatial crime mapping not only to enhance enforcement strategies but also to empower local communities. However, significant barriers such as limited access to technology, insufficient training, and inadequate infrastructure continue to hinder the adoption of these tools in Eastern Indonesia.

3.3 The Role of Predictive Analysis in Anti-Drug Strategies

Predictive analysis remains underdeveloped in the region, with most decision-making still based on experience and past trends rather than data-driven tools. As Informant 1, a Regional Police Officer, stated, *"We rely on past cases and field knowledge. We don't have algorithms or prediction software. It's all manual."* Similarly, Informant 2, a Regional BNN Official, noted, *"BNN headquarters has begun using predictive analysis tools, but it hasn't reached our regional level yet. We need proper systems and analysts to apply them here."* These statements highlight the technological and institutional gap in adopting predictive approaches at the local level.

In response to these limitations, Informant 3, a Community Leader, proposed involving local youth or universities in data collection efforts, saying, *"Students or researchers from nearby cities could help us gather local data. That way, we could build our own database of patterns."* This suggestion points to a practical and community-based solution to strengthen predictive capabilities. Overall, the insights reveal that while predictive models have the potential to improve targeting and prevention strategies, foundational investments in data infrastructure and technical capacity are essential for successful implementation.

3.4 Challenges and Opportunities in Technology Implementation

The interviews revealed several recurring challenges in implementing technological solutions. Informant 1, a Regional Police Officer, emphasized the issue of limited infrastructure, stating, *"Some areas don't even have consistent electricity or internet, so using advanced tools is not realistic yet."* Informant 2, a Regional BNN Official, pointed out the lack of skilled personnel, noting, *"Even if we had GIS software, we need trained people to operate it. Most of our staff aren't familiar with digital systems."* Furthermore, coordination gaps were highlighted by Informant 3, a Community Leader, who explained, *"BNN, the police, and local governments often work separately. We need a common platform to share information."*

Despite these barriers, each informant also highlighted opportunities for improvement. Informant 2 suggested a phased approach, stating, *"If we start with pilot projects in high-risk districts, with proper training and funding, I believe GIS and predictive tools could make a real difference."* Informant 3 added, *"We're open to partnerships with universities or NGOs. Even just building awareness about technology would help."* These insights support academic perspectives on the need for multi-stakeholder engagement in digital policing and the importance of integrating technology within local contexts.

CONCLUSION

This research concludes that drug trafficking in Eastern Indonesia is a growing threat, exacerbated by vast geographical access points, minimal technological oversight, and insufficient human resources. Although geospatial mapping and predictive analytics present promising tools for intervention, their implementation in the region remains limited and fragmented. The findings from three key informants indicate that while there is awareness of these tools, actual usage is hindered by several factors, including technological and infrastructure gaps—many high-risk areas lack basic connectivity and digital tools needed for effective monitoring. In addition, limited human

capacity remains a challenge, as most regional law enforcement and narcotics officers are not trained in geospatial or predictive systems. Furthermore, fragmented coordination between police, BNN, and local governments weakens inter-agency efforts.

Despite these barriers, the study uncovers substantial potential for future implementation. Informants expressed a strong willingness to adopt digital tools, especially if accompanied by proper training, partnerships with academic institutions, and pilot programs in hotspot regions. In conclusion, geospatial and predictive approaches must be adapted to local contexts and supported by institutional reform, inter-agency synergy, and community-based initiatives. Addressing these foundational issues will be critical for building a sustainable, technology-enhanced response to narcotics trafficking in Eastern Indonesia.

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