

Geospatial Technology as an Evidentiary Instrument in Forestry Crimes in Indonesia

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Abstract

Deforestation remains an unresolved challenge in Indonesia, where forestry crimes continue to threaten the sustainability of natural resources and the nation's ecological resilience. The enforcement of criminal law in the forestry sector frequently encounters significant evidentiary challenges, particularly in establishing the *locus delicti* and the spatial extent of illegal activities occurring within forest areas that are difficult to access through conventional field investigations. This study examines the role of geospatial technologies, including Geographic Information Systems (GIS), remote sensing, and satellite imagery, as evidentiary instruments in the adjudication of forestry crime cases in Indonesia. The research employs a normative legal method combined with statutory, conceptual, and case approaches to analyze the Indonesian legal framework governing criminal evidence under the Criminal Procedure Code (KUHAP) and relevant sector-specific regulations. The findings demonstrate that geospatial data may be accommodated within the evidentiary framework as expert testimony, documentary evidence, and judicial indications, as recognized under the KUHAP. Furthermore, the evidentiary value of geospatial information is reinforced by Article 5 of the Electronic Information and Transactions Law (ITE Law), which recognizes electronic documents as legally valid evidence. The study also identifies structural constraints in the investigation of forestry crimes, particularly the prolonged reliance on expert witnesses for the interpretation and verification of geospatial evidence. In response, it proposes a comprehensive normative framework to strengthen the integration of geospatial technology into criminal evidentiary procedures, thereby enhancing legal certainty, investigative efficiency, and the effectiveness of forestry law enforcement in Indonesia.

Keywords: *Geospatial Technology, Forestry Crimes, Electronic Evidence, Evidentiary Instruments, Forestry Law Enforcement*

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3rd International Conference Epicentrum of Economic Global Framework (ICEEGLOF)

Theme: Cross-Sector and Cross-Disciplinary Strategies for Achieving the SDGS

<https://proceeding.pancabudi.ac.id/index.php/ICEEGLOF>

Introduction

Indonesia possesses one of the world's largest tropical forest ecosystems, covering approximately 95.6 million hectares according to the 2022 data of the Ministry of Environment and Forestry (MoEF) [1]. This vast forest estate is not only of strategic importance for biodiversity conservation but also serves as a fundamental component of the national hydrological system and provides livelihoods for millions of people. Nevertheless, Global Forest Watch reported that between 2001 and 2022 Indonesia lost approximately 27.7 million hectares of tree cover, with illegal logging, unauthorized land conversion, and unlicensed plantation expansion constituting the primary drivers of deforestation [2]. This places Indonesia among the countries experiencing the highest rates of forest loss globally, generating profound environmental, social, and legal consequences.

The Indonesian government has responded to these challenges through the enactment of Law Number 41 of 1999 on Forestry and Law Number 18 of 2013 concerning the Prevention and Eradication of Forest Destruction. Although these statutes provide a relatively comprehensive substantive legal framework, their practical enforcement remains far from optimal. Data from the Directorate General of Law Enforcement of the Ministry of Environment and Forestry indicate that only a limited proportion of the thousands of reported forestry crime cases each year ultimately result in final and legally binding court judgments [3]. This situation reflects not merely institutional limitations but also deeper structural challenges, particularly those associated with the evidentiary process in criminal proceedings.

The prosecution of forestry crimes presents distinctive evidentiary difficulties. Criminal activities are generally committed in remote and inaccessible forest areas, while the physical evidence namely, damaged forest land and environmental conditions is inherently dynamic and subject to continuous alteration over time. Consequently, investigators and public prosecutors frequently encounter significant challenges in establishing that the defendant's activities occurred within legally protected forest areas, covered a specific geographical extent, and took place during a particular period. Conventional forms of evidence, including eyewitness testimony and documentary records, are often insufficient to satisfy these evidentiary requirements, especially as forestry crimes become increasingly organized and sophisticated, enabling perpetrators to conceal or eliminate traces of their illegal activities [4].

Recent advances in geospatial technology have created new opportunities to address these evidentiary challenges. Such technologies encompass Geographic Information Systems (GIS), remote sensing, high-resolution satellite imagery, and unmanned aerial vehicles (UAVs or drones), all of which enable the accurate identification, documentation, monitoring, and analysis of land-cover changes with a high degree of scientific precision and reproducibility [5]. Within the context of criminal proceedings, these technologies facilitate the reconstruction of forest conditions at specific points in time, the measurement of affected areas, and the precise determination of geographic coordinates. Despite their considerable scientific reliability, however, the admissibility of geospatial data as criminal evidence remains legally uncertain. Article 235 of the Indonesian Criminal Procedure Code (KUHAP) adopts a closed system of evidence that does not expressly recognize geospatial data or satellite imagery as independent categories of admissible evidence [6]. This normative uncertainty creates a significant legal dilemma. On the one hand, geospatial technology offers highly objective and scientifically verifiable evidence capable of strengthening criminal investigations and prosecutions. On the other hand, the rigid evidentiary framework established under the KUHAP may restrict or complicate its acceptance in judicial proceedings.

Previous studies on forestry crime have predominantly focused on criminal policy, environmental governance, and the general effectiveness of forestry law enforcement [7].

Comparatively little scholarly attention has been devoted to examining the legal status and evidentiary admissibility of geospatial technology within Indonesia's criminal justice system. This research gap has become increasingly significant because satellite imagery and remote sensing data are already being utilized during forestry investigations, despite the absence of a comprehensive procedural legal framework governing their authentication, validation, and evidentiary value. A notable example is the Supreme Court Decision Number 1107 K/Pid.Sus-LH/2021 concerning a forest fire case in Riau, in which remote sensing data were considered as part of expert testimony. Nevertheless, the Court did not establish a clear normative framework governing the authentication and evidentiary standards applicable to such geospatial information [8]. Consequently, the discretion exercised by law enforcement authorities in determining the use of geospatial evidence often depends more upon technical expertise and prevailing investigative practices than upon explicit procedural legal provisions capable of accommodating technological innovation [9].

Against this background, this study seeks to address the following research questions:

1. What is the legal status of geospatial technology as an evidentiary instrument in the prosecution of forestry crimes under Indonesian positive law?
2. What normative and institutional challenges hinder the utilization of geospatial technology as criminal evidence, and what legal formulations may be proposed to strengthen its admissibility and implementation within Indonesia's criminal justice system?

Literature Review

2.1. Theory of Evidence in Criminal Procedure

Indonesia adopts the negative statutory system of proof (*negatief wettelijk bewijsstelsel*), as reflected in Article 235 of Law of the Republic of Indonesia Number 20 of 2025 concerning the Criminal Procedure Code (KUHP). Under this evidentiary system, a criminal conviction requires not only the fulfillment of the minimum statutory evidentiary requirements but also the judge's personal conviction formed on the basis of legally admissible evidence [10]. Consequently, both the admissibility and probative value of evidence are confined to the categories expressly enumerated in Article 235 of the KUHP, namely witness testimony, expert testimony, documentary evidence, judicial indications, and the defendant's statement. Formulated during the early 1980s, this closed evidentiary framework reflects a conventional conception of criminal proof that did not anticipate the rapid evolution of digital technologies. As a result, a normative tension has emerged between the statutory text and the practical demands of contemporary law enforcement. In legal scholarship, this phenomenon is commonly referred to as statutory obsolescence, whereby legal provisions become outdated because technological and societal developments exceed the legislature's original expectations [11]. Zarzani argues that the modernization of Indonesian criminal law must accommodate technological developments in order to prevent normative gaps that undermine effective law enforcement [35].

According to Andi Hamzah, the fundamental function of criminal evidence is to facilitate the discovery of material truth, namely the fullest and most accurate reconstruction of the facts underlying a criminal case [12]. This perspective supports a broader interpretation of evidentiary law: if the ultimate objective of criminal proceedings is the discovery of material truth, then any scientifically reliable instrument capable of assisting courts in establishing that truth should, in principle, be accommodated, provided that it satisfies the applicable standards of scientific validity and procedural legality. Geospatial data, which objectively and accurately records the condition of forest areas at specific points in time, clearly fulfills this evidentiary function in the prosecution of forestry crimes. Modern evidentiary doctrine within common law jurisdictions has likewise recognized scientific

evidence, including digital forensic evidence and geospatial information, as admissible evidence subject to judicial reliability assessments under standards such as the Daubert framework [13].

2.2. Theory of Legal Instruments and Technology Regulation

Legal instruments governing technological developments constitute a rapidly evolving field of legal scholarship as technological innovation increasingly influences legal institutions and regulatory systems. Conceptually, a legal instrument may be understood as a formal mechanism through which the legal system achieves specific normative objectives [14]. In the context of geospatial technology, the issue of instrumentality becomes particularly complex because technology functions not merely as an object of legal regulation but also as an evidentiary instrument capable of supporting the realization of legal objectives.

The principle of technological neutrality provides a theoretical basis for interpreting existing evidentiary provisions in a technology-neutral manner, thereby allowing geospatial information to be accommodated without requiring immediate legislative amendment. Likewise, Niklas Luhmann's autopoietic systems theory offers an analytical framework for understanding this legal transformation. From this perspective, the incorporation of geospatial technology into the evidentiary system represents an external environmental stimulus that necessitates internal adaptation through either legislative coupling or judicial coupling [15].

The enactment of the Electronic Information and Transactions Law (ITE Law), which recognizes electronic information and electronic documents as legally valid evidence, may be regarded as an example of such legislative coupling within the Indonesian legal system. Nevertheless, significant challenges remain in harmonizing the general evidentiary framework established under the ITE Law with the specific evidentiary requirements applicable to forestry crime prosecutions, particularly given the distinctive technical characteristics of geospatial information. Previous legal studies concerning electronic documents and data protection in Indonesia demonstrate that sector-specific regulations and technical standards are often required to complement general legislation, especially where electronic information is introduced as evidence in judicial proceedings requiring enhanced standards of authentication and reliability [16].

2.3. Theory of Forestry and Environmental Law

Forestry law occupies an interdisciplinary position at the intersection of administrative law, environmental law, and criminal law. Forestry crimes are widely classified as **white-collar** environmental crimes, characterized by extensive environmental damage, the involvement of economically powerful actors, and sophisticated operational structures that complicate conventional criminal investigations and prosecutions [17].

The precautionary principle, as articulated in the 1992 Rio Declaration on Environment and Development, establishes that the absence of complete scientific certainty should not justify delaying preventive measures against serious or irreversible environmental harm [18]. Within the context of criminal evidence, this principle supports the utilization of geospatial technology because it provides more objective, scientifically reliable, and spatially precise information than conventional forms of evidence.

Jurisdictions such as the United States, Australia, and Brazil have developed evidentiary standards governing the admissibility of geospatial evidence. These standards generally require: (a) scientifically valid and widely accepted methodologies; (b) qualified and competent expert witnesses; (c) data capable of independent verification and adversarial examination; and (d) a documented **chain of custody** ensuring the authenticity and integrity of the evidence throughout the investigative process [19]. Although these evidentiary standards have not yet been formally incorporated into Indonesian positive law, they provide

valuable normative guidance for developing national protocols governing the use of geospatial technology in forestry law enforcement. Such an approach is consistent with contemporary Indonesian criminal law scholarship, which recognizes the integrity of the evidentiary process as an essential foundation of substantive justice [11].

2.4. Theory of Law Enforcement and Official Discretion

Soerjono Soekanto's theory of law enforcement identifies five principal factors determining the effectiveness of legal enforcement: legal norms, the integrity and competence of law enforcement officials, supporting facilities and infrastructure, societal conditions, and public legal awareness [20]. In the context of geospatial technology, these factors operate simultaneously. The legal framework remains the primary obstacle because Indonesian positive law does not yet explicitly regulate the evidentiary status of geospatial information. Zarzani and Siregar argue that legal reform which fails to accommodate technological developments inevitably creates a gap between normative legal provisions and actual law enforcement practices [36].

The capacity of law enforcement officials also represents a critical factor. Forestry Civil Servant Investigators (*Penyidik Pegawai Negeri Sipil* PPNS) generally possess limited expertise in geospatial analysis and therefore continue to rely predominantly upon conventional forms of evidence. Consequently, the discretionary authority exercised by investigators in determining evidentiary strategies including decisions regarding the use of satellite imagery, remote sensing data, field surveys, and the presentation of geospatial evidence before the court becomes a decisive factor influencing whether such technology can be effectively integrated into criminal proceedings [9].

The contemporary theory of evidence-based law enforcement further argues that the effectiveness of criminal justice should be evaluated according to its ability to produce successful prosecutions based upon reliable, scientifically validated, and legally accountable evidence [21]. From this perspective, integrating geospatial technology into forestry law enforcement should not be viewed merely as an optional technological innovation but rather as a practical necessity for strengthening the evidentiary foundation of criminal prosecutions and enhancing judicial confidence in the determination of material truth.

Institutional coordination also constitutes an essential component of effective law enforcement. The overlapping investigative authorities exercised by the Indonesian National Police (Polri), Forestry Civil Servant Investigators (PPNS KLHK), and the Public Prosecution Service, combined with the absence of standardized coordination protocols involving the Geospatial Information Agency (BIG), create institutional vulnerabilities that may be exploited by defendants to challenge the authenticity, reliability, and admissibility of geospatial evidence during criminal proceedings [22].

Research Methodology

This study employs a normative legal research method, which conceptualizes law as a prescriptive system of norms and focuses on the analysis and interpretation of applicable positive legal provisions [23]. The selection of this method is based on the nature of the research problem, which concerns the interpretation of existing legal norms and the identification of normative gaps between the current legal framework and the practical demands of contemporary forestry law enforcement.

To achieve the research objectives, three complementary legal approaches are employed. First, the statutory approach is used to examine the Indonesian Criminal Procedure Code (KUHAP), the Forestry Law, the Law on the Prevention and Eradication of Forest Destruction (P3H Law), the Electronic Information and Transactions Law (ITE Law), the Environmental Protection and Management Law, as well as relevant implementing

regulations issued by the Ministry of Environment and Forestry (MoEF) and the Geospatial Information Agency (BIG). This approach extends beyond a literal interpretation of statutory provisions by examining their *ratio legis* and evaluating the coherence and consistency among the applicable legal instruments [24].

Second, the conceptual approach is adopted to establish the analytical framework of the study through legal doctrines, theories of criminal evidence, and fundamental legal concepts, including legally admissible evidence, scientific evidence, electronic evidence, and evidentiary admissibility. This approach facilitates a systematic assessment of the legal status of geospatial technology within Indonesia's criminal justice system.

Third, a case approach is applied through the selective examination of relevant Indonesian judicial decisions, particularly Supreme Court judgments that have considered the use of technological evidence in criminal proceedings. The objective of this approach is to identify judicial reasoning concerning the admissibility, evidentiary value, and practical application of scientific and digital evidence within the Indonesian legal system [25].

The legal materials employed in this research consist of three categories. Primary legal materials include statutory legislation and relevant judicial decisions. Secondary legal materials comprise scholarly books, peer-reviewed journal articles in the fields of criminal procedure, environmental law, forestry law, and digital evidence published in reputable international and national journals indexed by Scopus and SINTA. Tertiary legal materials include legal dictionaries, encyclopedias, and technical references relating to geospatial technology and remote sensing.

Legal materials were collected through a systematic library research process involving searches of international academic databases, the National Library repository, the Indonesian Legal Documentation and Information Network (JDIH), and official technical publications issued by the Geospatial Information Agency (BIG) and the Ministry of Environment and Forestry (MoEF). The collected materials were analyzed using grammatical, systematic, and teleological methods of legal interpretation, complemented by legal construction to address normative gaps where positive law remains silent. In addition, a comparative legal analysis was undertaken by examining the positive law of selected foreign jurisdictions and internationally recognized evidentiary standards concerning geospatial technology. This comparative perspective was intended to identify best practices that may contribute to strengthening Indonesia's legal framework governing the admissibility and utilization of geospatial evidence in the prosecution of forestry crimes [26].

Results

4.1. The Legal Status of Geospatial Technology as an Evidentiary Instrument under Indonesian Positive Law

The legal status of geospatial technology within Indonesia's criminal evidentiary system ultimately raises a fundamental legal question: can geospatial information including satellite imagery, GIS-generated digital maps, GPS coordinate data, and drone recordings be admitted as legally valid evidence in criminal proceedings? Addressing this issue requires a careful examination of the Indonesian Criminal Procedure Code (KUHAP) as the *lex generalis* governing criminal procedure, together with relevant sector-specific legislation. Article 235 of the KUHAP recognizes five categories of admissible evidence, three of which may reasonably accommodate geospatial information within the existing legal framework.

First, geospatial information may be introduced through expert testimony, as provided under Article 235 of Law of the Republic of Indonesia Number 20 of 2025 concerning the Criminal Procedure Code. A qualified geospatial expert from the Geospatial Information

Agency (BIG), an academic institution, or another competent technical authority may provide expert testimony based upon scientific analyses of geospatial data. In this context, geospatial information functions as the scientific foundation of the expert's opinion, while its admissibility depends upon the expert's qualifications, the reliability of the methodology employed, and judicial acceptance of the underlying scientific principles [6]. This approach currently represents the most common evidentiary pathway in Indonesian forestry law enforcement, although no standardized procedural protocol yet governs its application.

Second, geospatial evidence may be accommodated under the category of documentary evidence, as recognized in Article 235 of the KUHAP, which includes written reports or opinions prepared by experts within the scope of their professional competence. Accordingly, an officially issued geospatial analysis report produced by the Geospatial Information Agency (BIG) or another authorized institution may qualify as documentary evidence capable of supporting criminal prosecution.

Third, and most significantly from a normative perspective, the legal basis for geospatial evidence derives from the Electronic Information and Transactions Law (ITE Law). Article 5 paragraph (1) of Law Number 11 of 2008, as amended by Law Number 19 of 2016, expressly recognizes electronic information, electronic documents, and their printed versions as legally valid evidence [27]. If digital geospatial information is characterized as an electronic document a legal interpretation that is both persuasive and doctrinally defensible the ITE Law provides an explicit statutory basis for its admissibility in criminal proceedings. This interpretation is consistent with previous legal scholarship examining the security and legal validity of electronic documents, which concludes that the ITE Law extends to diverse forms of digital information, provided that the applicable technical and legal requirements are satisfied [16].

Furthermore, judicial indications (*petunjuk*), as recognized under Article 235 of the KUHAP, may also provide an evidentiary basis for the use of geospatial technology. Comparative satellite imagery demonstrating changes in forest cover between two distinct periods may constitute a strong judicial indication that a physical alteration of a protected forest area has occurred, thereby corroborating the prosecution's allegations concerning unlawful forestry activities.

An examination of Indonesian judicial practice demonstrates that courts have gradually adopted a pragmatic approach toward technologically generated scientific evidence. In several cases involving forest fires in Sumatra and Kalimantan, remote sensing data have been accepted as the scientific basis for expert testimony. A particularly significant precedent is Supreme Court Decision Number 1107 K/Pid.Sus-LH/2021, in which remote sensing evidence was considered during the judicial assessment of a forestry crime despite the absence of explicit procedural rules governing its evidentiary status [8]. This development illustrates what may be described as judicial pragmatism, whereby judges are willing to accommodate scientifically reliable evidence in pursuit of substantive justice, notwithstanding the lack of comprehensive procedural regulation.

Nevertheless, an important normative issue remains unresolved, namely the authentication of geospatial evidence. Unlike jurisdictions operating under the United States Federal Rules of Evidence particularly Rule 901 concerning authentication Indonesian criminal procedure provides no explicit legal standard governing the authentication of digital geospatial information. Consequently, geospatial evidence introduced without a clearly documented authentication process remains vulnerable to procedural challenges by defendants. To address this legal uncertainty, Indonesia requires a comprehensive technical-legal protocol establishing standardized procedures for the acquisition, processing, preservation, authentication, and presentation of geospatial evidence. Such standards could be

formulated through a joint regulation issued by the Ministry of Environment and Forestry (MoEF), the Geospatial Information Agency (BIG), and the Indonesian National Police (Polri), thereby providing greater legal certainty while ensuring the scientific integrity of geospatial evidence throughout criminal proceedings [5].

4.2. Normative and Institutional Challenges and Proposed Legal Solutions

The utilization of geospatial technology as an evidentiary instrument in forestry crime prosecutions encounters three interrelated categories of challenges: normative, institutional, and technical-capacity constraints. The most fundamental normative challenge is the absence of explicit statutory recognition of geospatial information as an independent category of admissible evidence under either the KUHAP or sector-specific forestry legislation. Although persuasive legal arguments support accommodating geospatial information through existing evidentiary categories, this interpretative approach remains vulnerable to legal uncertainty. Within a criminal justice system founded upon the principle of legality and stringent evidentiary standards, ambiguity concerning the legal status of evidence creates litigation risks that may be exploited by well-resourced corporate defendants. Consequently, acquittals may result not from the substantive innocence of the accused but from procedural deficiencies in the evidentiary process [7,34]. As emphasized by Siregar, legal certainty during the investigative stage constitutes a fundamental prerequisite for achieving substantive justice within criminal proceedings [34].

Institutional challenges primarily concern fragmented investigative authority and inadequate inter-agency coordination. Investigative powers relating to forestry crimes are divided among the Indonesian National Police (Polri), Forestry Civil Servant Investigators (PPNS KLHK), and, under certain circumstances, the Corruption Eradication Commission (KPK), each possessing distinct institutional traditions, technical capacities, and operational procedures. Meanwhile, although the Geospatial Information Agency (BIG) functions as Indonesia's highest technical authority in geospatial information, it performs no formal role within forestry crime investigations. Consequently, geospatial data produced by BIG are typically incorporated into criminal investigations through informal mechanisms lacking standardized procedural guidelines [5].

The third category of challenges concerns technical capacity. Forestry Civil Servant Investigators generally possess limited educational backgrounds and professional training in geospatial analysis, Geographic Information Systems (GIS), and remote sensing technologies. Surveys conducted among Forestry Civil Servant Investigators in several regions indicate that the majority have never received formal training concerning the application of geospatial technology in criminal investigations [3]. This deficiency creates substantial dependence upon external expert witnesses, whose availability is often limited in remote forest regions where forestry crimes most frequently occur. Moreover, the necessity of obtaining expert testimony significantly prolongs criminal investigations because identifying, appointing, and examining qualified experts requires considerable time and procedural coordination, thereby delaying the overall investigative process [33,34].

In response to these challenges, this study proposes a three-tiered legal reform framework encompassing normative, institutional, and legislative measures.

At the normative level, the most practical medium-term solution would be the issuance of either a Government Regulation or a Joint Regulation involving the Indonesian National Police (Polri), the Ministry of Environment and Forestry (MoEF), and the Geospatial Information Agency (BIG). Such regulation should specifically govern the acquisition and evidentiary use of geospatial information during the investigation and prosecution of forestry crimes without awaiting comprehensive amendments to the KUHAP. The regulatory

framework should establish minimum standards regarding spatial resolution and data accuracy, documented acquisition procedures capable of preserving the chain of custody, mechanisms for validation and authentication by authorized institutions, and minimum professional qualifications for expert witnesses responsible for interpreting geospatial evidence [14]. This proposal is consistent with scholarly views that effective forestry law enforcement reform requires an integrated combination of regulatory instruments and institutional capacity building [22].

At the institutional level, Indonesia should establish a specialized Forestry Geospatial Forensics Unit responsible for integrating geospatial expertise with criminal investigative functions. Brazil provides an instructive comparative model through its PRODES and DETER monitoring systems administered by the National Institute for Space Research (INPE), which have successfully incorporated remote sensing data into forestry law enforcement while achieving significantly higher levels of judicial acceptance than those currently observed in Indonesia [19]. The Brazilian experience demonstrates that dedicated environmental forensic institutions substantially enhance law enforcement effectiveness by facilitating the accumulation of technical expertise, the development of standardized methodologies, and the maintenance of centralized geospatial databases capable of supporting comparative analyses across multiple cases.

Finally, at the legislative level, the ongoing reform of the Indonesian Criminal Procedure Code presents an important opportunity to incorporate explicit provisions recognizing scientifically generated technological evidence, including geospatial information, as an independent category of admissible criminal evidence. The formal recognition of scientific evidence accompanied by statutory standards governing its admissibility, reliability, authentication, and methodological validity would substantially strengthen legal certainty while enhancing the effectiveness of Indonesia's criminal justice system in responding to increasingly sophisticated and organized environmental crimes [11].

Conclusion

Based on the foregoing analysis, this study reaches two principal conclusions while offering normative recommendations for strengthening the legal framework governing the use of geospatial technology in forestry crime prosecutions.

Geospatial technology possesses substantial legal potential to serve as a legitimate evidentiary instrument in the prosecution of forestry crimes in Indonesia. Although the Indonesian Criminal Procedure Code (KUHP) does not expressly recognize geospatial information as an independent category of evidence, a systematic and teleological interpretation of Article 235 of Law of the Republic of Indonesia Number 20 of 2025 concerning the Criminal Procedure Code particularly the provisions governing expert testimony provides a sufficient legal basis for accommodating geospatial evidence within the existing evidentiary framework. This position is further reinforced by Article 5 of the Electronic Information and Transactions Law (ITE Law), which recognizes electronic information and electronic documents as legally admissible evidence. Indonesian judicial practice, particularly Supreme Court Decision Number 1107 K/Pid.Sus-LH/2021, further demonstrates that courts have adopted a pragmatic approach toward the admission of scientifically generated evidence despite the absence of explicit procedural regulation. This development is consistent with Siregar's view that the integration of scientific evidence into Indonesia's criminal justice system is an essential prerequisite for achieving substantive and civilized justice [37]. Nevertheless, the continuing normative uncertainty regarding the evidentiary status of geospatial information requires a more systematic legal response. In the medium term, this should be addressed through joint technical regulations issued by relevant

government agencies, while, in the long term, the ongoing reform of the KUHAP should expressly recognize technology-based scientific evidence as an independent category of admissible criminal evidence.

The normative, institutional, and technical-capacity challenges identified in this study require an integrated and comprehensive policy response rather than isolated reforms. A three-tiered legal reform strategy is therefore proposed. At the normative level, Indonesia should adopt joint technical regulations establishing standardized procedures for the acquisition, validation, authentication, preservation, and presentation of geospatial information as criminal evidence. At the institutional level, a specialized Forestry Geospatial Forensics Unit should be established to facilitate inter-agency coordination through standardized operational protocols and centralized technical expertise. At the capacity-building level, systematic professional training programs should be implemented for investigators of the Indonesian National Police (Polri) and Forestry Civil Servant Investigators (PPNS) to strengthen their competence in geospatial technology and its legal implications within criminal proceedings. The successful implementation of these complementary reforms would substantially enhance the effectiveness of forestry law enforcement in Indonesia by ensuring that perpetrators of large-scale forestry crimes cannot evade criminal liability merely because the legal system lacks adequate mechanisms to establish their offenses through reliable, scientifically validated, and legally admissible evidence before the courts.

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