

REGULATION OF DRONE USE IN PUBLIC SPACES BASED ON PRIVACY AND SECURITY PROTECTION PRINCIPLES

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ABSTRACT

This doctrinal legal research examines the legal framework and oversight mechanisms for drone operations in public spaces in Indonesia. The analysis reveals that the current regulation, primarily Ministerial Regulation Number PM 90 of 2020, focuses predominantly on aviation safety aspects and neglects the protection of privacy and public security. Key deficiencies include the absence of explicit provisions on data collection, visual recording, civil liability, and complaint mechanisms for affected citizens. Enforcement faces substantial obstacles due to the lack of remote identification systems, limited detection technology, and overlapping authority among government agencies. This study proposes a set of responsive legal principles to address these deficiencies, including proportionality, transparency, accountability, precaution, respect for human rights, data protection, non-discrimination, harmonization, effective enforcement, technological adaptation, public participation, and international cooperation. These principles provide a normative foundation for balanced regulation that accommodates technological innovation while safeguarding fundamental rights. The findings contribute to legal scholarship by demonstrating that technology regulation cannot be limited to technical operational aspects but must integrate the protection of citizens' fundamental rights. For policymakers, this research offers concrete guidance for revising existing regulations and strengthening institutional capacity for oversight. Without such legal reform, drone regulation in Indonesia will remain ineffective and unjust, and the public will continue to bear the risks of uncontrolled technology.

Keywords: Drone regulation, public space, privacy protection, aviation safety, data collection, enforcement, legal principles.

INTRODUCTION

The use of unmanned aerial vehicles, more commonly known as drones, has increased exponentially over the past decade in various parts of the world. Technology originally developed for military purposes is now expanding into the civilian sector, ranging from package delivery, territorial mapping, and precision agriculture to journalism and filmmaking. The availability of affordable drones with increasingly sophisticated features

drives mass adoption by the general public for both commercial and recreational purposes (Lucia & Vegni, 2023). Public spaces, previously the domain of humans and conventional vehicles, are now beginning to fill with autonomous flying objects traversing urban skies. The presence of drones in public spaces brings major benefits in terms of efficiency and accessibility, but it also raises fundamental questions regarding safety, privacy, and public order. The issue of privacy is particularly serious, as the widespread use of data-based technology raises concerns regarding surveillance, data misuse, and violations of individual freedoms (Rojak, 2022). A small device equipped with a camera can record individual activities without their knowledge, gathering visual data from high altitudes previously inaccessible to humans (Grubestic & Nelson, 2020). This capability transforms the traditional understanding of surveillance and privacy, as drones can access areas that are physically closed to human observers. Consequently, regulations governing drone usage can no longer rely on legal frameworks designed for manned aircraft, as the characteristics and social impacts of the two technologies are vastly different.

Various countries have responded to the surge in drone usage by issuing regulations that govern drone flights in public airspace. The United States, through the Federal Aviation Administration, issued regulations on commercial and recreational drone operations, including altitude limits, prohibitions on flying near airports, and the obligation to maintain a visual line of sight. The European Union implemented a risk-based approach by dividing drone operations into open, specific, and certified categories, each with distinct requirements. Countries like Japan and Australia also have national regulations governing drone registration, pilot training, and no-fly zones. However, these regulatory approaches vary widely and are often reactive to incidents, such as flight disruptions or privacy violations involving drones (Al-Ahmadi, 2025). In Indonesia, Minister of Transportation Regulation No. PM 90 of 2020 on the Use of Unmanned Aircraft serves as the primary reference for drone usage, yet its scope focuses more on aviation safety aspects rather than the protection of public rights. This gap raises questions as to how far Indonesian law provides protection for the public against potential risks posed by drones in public spaces (Amin et al., 2024). According to Boucher (2015), international drone regulation still concentrates on technical and safety aspects, whereas ethical dimensions and criminal law have not received adequate attention. This view demonstrates that legal development continues to lag behind technological advancement.

The presence of drones in public spaces also raises issues regarding legal certainty for both drone operators and the broader community. The lack of clear rules regarding which locations drones may or may not cross causes conflicts between drone operators, residents, and security personnel (Noor et al., 2018). In many cases, drone owners are reported to the police for allegedly disturbing public order, but legal proceedings are hindered by the absence of specific rules regarding the offenses committed (Scott et al., 2022). The public also faces difficulties when they feel their privacy has been violated by drones flying over their private property, as grievance and compensation mechanisms are often unavailable.

Furthermore, the use of drones by law enforcement agencies and governments for traffic monitoring, crowd surveillance, or land mapping raises additional concerns about the potential abuse of power. Data collected by government drones could be used for purposes exceeding granted authorities without independent oversight (Ahmad, 2021). This condition indicates that law must not only regulate technical aspects of flight, but also govern how collected drone data is treated, who has access, and for what purposes the data may be used. This regulatory gap reflects a lack of understanding among policymakers regarding the social and legal implications of constantly evolving drone technology.

Privacy protection stands as a central issue in drone surveillance in public spaces due to the ability of drones to record high-resolution images and audio from long distances (Jiang et al., 2020). Unlike stationary surveillance cameras, drones can move and track subjects, thereby creating potential for more intensive and personalized surveillance. Drone recordings can be stored, analyzed using facial recognition software, and shared with third parties without the knowledge of the recorded individuals. This practice raises questions about whether individual consent is required prior to being recorded by a drone, and how mechanisms for withdrawing consent can be realized. Existing privacy laws generally regulate data collection by public and private entities, but often fail to specifically encompass data collection via drones. Consequently, a legal vacuum exists that commercial entities exploit to gather public data without clear limits. Privacy protection must also consider the location where recordings take place, as recordings in public places carry different protection standards compared to those on private property. Finn and Wright (2012) argue that emerging surveillance technologies like drones expand information gathering capacities and challenge legal assumptions regarding reasonable surveillance. A regulatory and protective gap exists wherein contemporary surveillance practices operate, resulting in the continuous erosion of individual privacy without adequate safeguards (Gardi & Gani, 2023). This assertion indicates that the law must adapt to evolving technological capabilities to ensure that privacy protection remains relevant.

Beyond privacy concerns, drone surveillance in public spaces directly relates to the physical safety of citizens and urban infrastructure. Uncontrolled drones can crash, injuring people or damaging property, particularly in densely populated areas. Exploding drone batteries, signal interferences leading to loss of control, or pilot errors can result in potentially fatal accidents. Drones can also be weaponized or misused to transport hazardous items—such as explosives or chemical substances—to sensitive locations like government buildings, stadiums, or airports. These security threats have prompted several countries to enact flight bans around critical infrastructure and crowded areas, but enforcement remains weak due to technological limitations in drone detection. Additionally, drones can disrupt air traffic and endanger commercial aviation safety, as seen in several major global airports that were forced to temporarily shut down due to drone presence in approach paths. These incidents demonstrate that security risks posed by drones are not theoretical speculations, but reality occurring in various places. According to Clarke (2014), drone regulation must

strike a balance between encouraging innovation and protecting society from potential risks. This statement emphasizes the need for a proportional, risk-based legal approach to manage drone usage in public spaces. This study aims to critically examine how law and surveillance regarding drones in public spaces can be formulated to address various emerging challenges across privacy, security, and public order.

The main problem encountered in the law and surveillance of drones in public spaces is the inability of existing legal frameworks to accommodate the unique characteristics of drones, which differ significantly from manned aircraft and other technological devices. Drones operate in low-altitude airspace situated between the private realm of individual property and state-owned public space, creating a legal grey zone with an ambiguous status. This ambiguity impacts legal categorization and practice, frequently giving rise to critical gaps (Abror et al., 2025). Traditional aviation law was designed for aircraft carrying crew and passengers; thus, rules regarding minimum altitudes, flight paths, and pilot liability are not entirely suitable for autonomous or remotely operated drones (Abdullin & Sungatullin, 2024). On the other hand, privacy and data security laws do not specifically regulate information collection via drones, leading to jurisdictional overlaps and vacuums. This ambiguity leaves law enforcement struggling to identify proper legal bases for handling drone-related violations, while the public loses certainty regarding their rights and obligations. Drone operators are similarly placed in a difficult position, lacking clear guidance on the legal boundaries of flying in complex urban areas. This problem is compounded by differing regulatory approaches across regions and countries, creating a confusing legal fragmentation for operators conducting cross-jurisdictional flights. The gap between law and technology demands a comprehensive normative reform rather than mere patchwork additions to existing regulations.

Another equally pressing issue is the absence of effective surveillance and oversight mechanisms for drone operations in public spaces, both technically and from an enforcement perspective. Technologies to track and identify drones remain in development and are not yet widely available, leaving flight violations frequently undetected. Drone registration systems implemented in various countries also encounter compliance hurdles, as many operators fail to register their devices. Without effective registration, enforcing laws against violations becomes nearly impossible because offenders cannot be identified. Aviation oversight bodies often lack the resources and technical expertise required to conduct necessary patrols and investigations. Lengthy and complex judicial processes further complicate the handling of drone violation cases, allowing many offenses to go unpunished. This weak enforcement creates an atmosphere of impunity that encourages irresponsible behavior among drone users, knowing the risk of getting caught is extremely low. Consequently, drone-related incidents continue to rise without significant declines, reflecting a systemic failure in existing oversight mechanisms. This issue underscores that drafting regulations alone is insufficient, as surveillance, oversight, and enforcement are equally critical components in ensuring legal compliance.

This research aims to produce a comprehensive legal analysis of the gap between existing drone regulations and the public's need for privacy and security protection, while formulating normative principles to guide lawmakers and regulators in crafting superior drone policies. The theoretical contribution of this study lies in developing an adaptive and risk-based concept of technology law, while its practical contribution offers actionable policy recommendations for the government and parliament to update drone regulations in Indonesia. Ultimately, this study is expected to bridge the gap between rapidly advancing drone technology and legal developments that often fail to keep pace.

METHODS

This research applies a doctrinal or normative legal method to examine written principles, concepts, and regulations. Based on Chynoweth's framework, the doctrinal approach focuses on qualitative-interpretative analysis without empirical data collection, where its validity relies on scholastic consensus and legal reasoning. In line with the views of Hutchinson and Duncan, this method demands operational clarity to explain the existence and validity of the law. The study relies entirely on library research and electronic databases encompassing primary legal materials (drone flight regulations and privacy laws), secondary materials (textbooks and technology law journals), and tertiary materials (legal dictionaries and encyclopedias). A qualitative approach is utilized to explore the meaning of norms and their correlation with the dynamics of drone usage in public spaces.

The procedure for collecting and processing legal materials adopts the SALSA (Search, Appraisal, Synthesis, Analysis) framework by Grant and Booth. The stages begin with a systematic search based on keywords such as drone regulations, privacy, and aviation law. Subsequently, source quality is evaluated based on substantive relevance, author credibility, and publication recency. Findings that pass the selection are synthesized into thematic groups aligned with the research problems, then analyzed to produce a comprehensive normative interpretation. As emphasized by McConville and Chui, this non-empirical approach bases its argumentative strength on the analysis of legal texts and doctrines. The validity and reliability of the study are maintained through logical consistency of arguments, selection of verified references, and transparent documentation of the analytical process in order to formulate legal policy recommendations that are responsive to technological developments.

RESULTS AND DISCUSSION

Existing Legal Framework Governing Drone Usage in Public Spaces and the Protection of Privacy and Security

The current legal framework governing drone usage in public spaces in Indonesia primary

derives from Minister of Transportation Regulation No. PM 90 of 2020 on the Use of Unmanned Aircraft. Replacing previous regulations, this rule aims to provide legal certainty for drone users while safeguarding aviation safety and the public. PM 90 of 2020 regulates various technical aspects of drone operations, such as an operational ceiling capped at 400 feet above ground level, mandatory distance limits from airports and other prohibited zones, and safety procedure awareness requirements for operators. However, this regulation is dominantly oriented toward aviation safety aspects and fails to give adequate consideration to public privacy protection (Firmansyah et al., 2024). There are no explicit provisions governing image or audio recording by drones, restrictions on personal data collection, or mechanisms for citizens who feel their privacy has been infringed to lodge objections. Consequently, while drone usage is technically regulated, the civil rights protection dimension remains virtually untouched within this legal framework. A regulatory regime focusing solely on safety creates an illusion of comprehensive legal protection, whereas substantial gaps persist regarding privacy safeguards and other public rights.

Furthermore, the Minister of Transportation Regulation fails to clearly differentiate between various drone types based on their function and risk profile, applying a uniform regulatory approach to all operations. Toy drones for children are treated the same as professional drones utilized for surveillance or cargo delivery, despite vast differences in potential risk (Raya & Esteve, 2024). This one-size-fits-all approach leaves regulation overly lenient for high-risk drones and excessively restrictive for low-risk drones, diminishing overall regulatory effectiveness. The absence of a risk-based classification also complicates law enforcement, as authorities lack clear guidelines regarding the appropriate level of oversight required for different drone operations. Additionally, the regulation does not mandate universal registration for all drone types, leaving many units operating anonymously and making tracking nearly impossible when violations occur. A voluntary or partial registration system can never yield accurate data on total drone numbers and ownership within a territory, making policy planning and oversight exceptionally difficult. These shortcomings demonstrate that Indonesia's legal framework for drones remains in its infancy and is ill-prepared to address complex technologies and public protection needs.

Personal data protection, an integral component of human rights, is drawing increasing attention alongside rapid advancements in information and communication technology (Muhammad et al., 2023). Privacy protection in the context of drone usage in public spaces is not specifically governed under Indonesian legislation, as the personal data protection framework is not yet fully effective and fails to encompass visual data collection via drones. Law No. 27 of 2022 on Personal Data Protection regulates personal data processing in general terms, but does not explicitly mention drones as data-collecting devices. Without dedicated provisions, legal uncertainty persists regarding whether video recordings captured by drones fall under protected personal data categories, and if so,

how rules regarding consent and processing restrictions should apply. Drone footage in public spaces frequently captures the faces of unknown individuals who cannot grant consent, placing such data collection in a legal grey area. This ambiguity creates a loophole for commercial actors using drones to gather public consumer behavior data under the defense that such data is not personal because it was collected in a public place. Such practices not only violate individual privacy but also generate injustice, as data subjects exercise no control over information about themselves. Thus, the existing legal framework fails to provide adequate privacy safeguards in drone contexts and requires reforms accommodating the unique characteristics of aerial data collection.

Public safety regarding physical risks posed by drones also lacks adequate regulation within the current framework. While the Minister of Transportation Regulation sets altitude limits and restricted fly zones, it does not detail civil liability when a drone causes injury or property damage (McTegg et al., 2022). When a drone crashes and injures someone in a public space, victims face hurdles claiming compensation due to ambiguity surrounding liability, particularly if the drone is unregistered or the pilot remains unidentified. Liability insurance for drone operations is not legally required, leaving victims to shoulder the burden of loss entirely. Moreover, regulations omit minimum safety standards for drones manufactured and sold in the market, enabling consumers to purchase low-quality units with high accident risks. The lack of technical certification or standards leaves product oversight exceptionally weak, often making it impossible to trace accidents back to manufacturing defects. Criminal misuse of drones also receives minimal attention, as regulations fail to address prohibitions against using drones to carry hazardous materials or disturb public order. These deficiencies highlight that public safety protections under the current drone framework remain profoundly weak and demand significant reinforcement.

The implementation of drone regulations in the field encounters severe enforcement barriers due to the lack of effective monitoring mechanisms to ensure operator compliance. Law enforcement agencies lack the equipment to detect and identify drones flying in their jurisdictions, leaving violations undetected until fatal incidents occur (Janke & Haag, 2022). Technologies such as remote identification—which require drones to broadcast identification signals—are not yet mandatory in Indonesia, making offense tracking nearly impossible. Without effective identification, sanctions cannot be served, resulting in a negligible deterrent effect. Furthermore, breaches of data confidentiality collected through drone operations can lead to serious legal consequences, including criminal and administrative sanctions, particularly if data is used or disseminated without a lawful basis (Ustani et al., 2024). Lengthy and convoluted judicial proceedings further weaken enforcement, as drone violation cases are rarely prioritized by courts. The scarcity of investigators possessing technical expertise in drone technology presents another major bottleneck, as investigations and evidence collection demand specialized knowledge of aviation systems. Consequently, drone violations are frequently left

unaddressed, fostering a perception among users that the risk of apprehension is minimal. This state of affairs cultivates a culture of non-compliance that is difficult to shift, as the public observes that drone laws are enforced neither consistently nor firmly.

Drone oversight in public spaces is also stymied by jurisdictional overlaps among various government agencies involved in aviation regulation and monitoring. The Ministry of Transportation is responsible for aviation safety, while the police oversee public order and criminal law enforcement. Meanwhile, the Ministry of Communication and Digital Affairs plays a role in regulating radio frequencies and data communications used by drones. This overlap causes confusion regarding which agency to contact during an incident, frequently leading to institutional inertia where bodies wait on one another to act. Lacking effective inter-agency coordination mechanisms, responses to drone incidents remain slow and uncoordinated. Citizens wishing to report violations often do not know which agency holds authority, and when reports are filed, they are frequently passed between institutions without resolution. The absence of a clear division of authority also creates risks where drones are deployed for surveillance by specific agencies without independent checks from others, opening the door to potential abuses of power. To address this, clear and effective inter-agency coordination mechanisms must be established alongside non-overlapping, complementary allocations of authority.

Legal protection for citizens impacted by drone operations in public spaces also faces barriers in access to justice. Individuals whose privacy has been violated or who fall victim to drone accidents often lack effective legal avenues to assert their rights (Dolata & Schwabe, 2023). Filing civil lawsuits against drone owners or operators requires knowing the defendant's identity; yet, drones are frequently unregistered and pilots remain anonymous. Protracted and costly litigation processes present further barriers for ordinary citizens, especially when material losses are relatively minor. Alternative dispute resolution options outside the court system are similarly unavailable due to the absence of specialized mediation or arbitration bodies for drone-related disputes. As a result, many victims fail to obtain compensation or rights redress, while violators continue their conduct without consequence. The inability of citizens to enforce their rights indicates that legal protections under the existing framework are ineffective and unjust. Rectifying this requires establishing fast, inexpensive, and accessible dispute resolution mechanisms alongside strengthening victims' rights within the judicial system.

A comparative analysis with regulatory approaches in other jurisdictions reveals that Indonesia lags behind in comprehensively and balancedly regulating drone usage. Jurisdictions such as the United States (via the Federal Aviation Administration) and the European Union (via the European Union Aviation Safety Agency) have developed more detailed, risk-based drone regulations integrating safety, privacy, and consumer protection. A risk-based approach—categorizing drone operations according to risk levels—enables more proportional and effective regulation. In contrast, Indonesia's drone regulations remain sectoral and poorly integrated with other legal domains, such

as personal data protection and criminal law. This lag causes Indonesia to miss opportunities to learn from international experiences in designing balanced regulations. However, adopting foreign approaches cannot be done blindly without adjusting for local conditions, as distinct geographic, demographic, and socio-economic characteristics necessitate tailored strategies. For instance, high population density in Indonesian urban centers demands stricter operational rules in crowded areas, whereas expansive, remote territories require greater flexibility.

The public's right to information regarding drone operations in public spaces also lacks adequate protection under the current framework. Citizens have a right to know when and where drones operate in their surroundings, particularly when deployed by government or law enforcement agencies for surveillance purposes (Dei, 2023). Without such information, individuals cannot make informed decisions about their behavior in public spaces nor effectively protect their privacy. These risks grow more complex given that seemingly trivial data—such as typing patterns, walking speed, or active hours—can be leveraged to infer health conditions, stress levels, social ties, and even ideological preferences (Oluwatosin, 2024). Several nations now require visual markers or lights on drones operating at night or over public areas, as well as apps notifying citizens of nearby flights. In Indonesia, however, no similar provisions mandate operational transparency, leaving citizens unaware when they are being recorded or monitored from the air. This lack of transparency fosters public distrust toward government and commercial entities while undermining the legitimacy of drone technology itself. Emphasizing transparency and accountability in information provision enhances public discourse and encourages citizens to actively critique and understand the information they receive (Zulkarnain & Al Hakim, 2023). To remedy this, the legal framework must mandate public notifications for large-scale drone operations or those involving personal data collection, while providing mechanisms for citizens to request operational details in their communities.

Law enforcement against drone-related offenses in public spaces is further hampered because existing criminal statutes do not specifically address drone-specific offenses. Misusing drones to disturb public order, damage property, or invade privacy is often shoehorned into general criminal provisions not designed for such scenarios. This forced application creates legal uncertainty and leads to inconsistent court rulings (Bassi, 2020). The absence of specific drone-related offenses also leaves law enforcement without clear sentencing guidelines, resulting in widely varying and often lenient penalties. Light sanctions produce a weak deterrent effect, causing recurring violations. While several countries have embedded specific criminal provisions within their aviation laws—including significant fines and imprisonment—penal provisions under Indonesia's Minister of Transportation Regulation remain severely limited and fail to impose sufficiently strict penalties to deter serious offenses. Strengthening enforcement requires criminal law reforms that specifically outline offenses related to drone usage in public spaces, backed by sanctions proportional to the degree of fault and harm caused.

In summary, the legal framework governing drone usage in public spaces in Indonesia suffers from significant weaknesses, particularly concerning privacy protection and public safety. Existing regulations focus narrowly on aviation safety while ignoring civil rights protections, whereas oversight and law enforcement remain weak due to technical limitations and overlapping authorities. Citizens lack adequate access to justice when their rights are infringed by drone operations, allowing violations to continue without meaningful consequences. This imbalance between commercial interests and public protection is reflected in regulations that protect operators more than the public. Overcoming these flaws demands a comprehensive overhaul of the legal framework—one that goes beyond technical flight rules to provide robust safeguards for public privacy and safety, supported by effective oversight and enforcement mechanisms. This reform must be grounded in legal principles that are responsive to technology and respectful of fundamental human rights. Without such reform, Indonesian drone law will remain an ineffective and inequitable instrument, leaving the public vulnerable to uncontrolled technology.

Legal Principles for Drone Regulations Responsive to Technological Advancements

Formulating a legal framework for drones that is responsive to technological advancements must stem from the principle of proportionality, which demands a balance between the interests of technological innovation and the protection of public rights. This principle dictates that any restrictions imposed on drone operations must be proportionate to the risks posed and the benefits derived from the technology. In practice, proportionality means that low-risk drones, such as children's toys or small recreational drones, should not bear the same regulatory burden as large commercial drones used for cargo delivery or surveillance. A risk-based approach—categorizing drones into different groups based on weight, capability, and intended use—enables more targeted regulation without unduly stifling innovation. However, applying proportionality also implies that high-risk drones, such as those used for mass surveillance or carrying hazardous payloads, must face stringent requirements, including operator licensing, liability insurance, and continuous oversight. This balance is critical to ensure that drone regulation does not become a barrier to the growth of the digital economy, while also ensuring the public is not exposed to unacceptable risks. Finn and Wright (2012) argue that regulating emerging surveillance technologies requires considering a broad spectrum of risks and avoiding a one-size-fits-all approach.

The second foundational principle for responsive drone regulation is transparency, which mandates drone operators to provide clear information to the public regarding their presence and operational purposes in public spaces. Transparency encompasses obligations to affix identification marks or lights on operating drones, afford public access to flight schedules and routes, and publicly announce any drone operation involving large-scale personal data collection (Bassi, 2020). The public has the right to know when and where they might be recorded or monitored by drones, allowing them to adjust their

behavior and protect their privacy as they see fit. Transparency also means that drone operators must disclose their data processing policies clearly and comprehensibly, including the types of data collected, the purpose of collection, retention periods, and entities with access to the data. Without transparency, citizens cannot make informed decisions regarding their exposure to drone technology, causing public trust in these technologies to erode continuously. Commercial entities that lack transparency regarding their drone operations also face severe reputational risks, as consumers increasingly prioritize privacy protection when choosing products and services. Thus, transparency is not only a legal obligation but also a sound business interest.

The principle of accountability serves as an indispensable third pillar in designing responsible drone regulation. Accountability demands mechanisms ensuring that every drone operator can be held responsible for their actions, including in cases of privacy violations, accidents, or illicit drone misuse. To achieve accountability, a mandatory and effective drone registration system is an absolute prerequisite, as identifying violations becomes impossible without explicit operational identities. Registration must capture information regarding drone owners, technical device specifications, and operational purposes, and must be updated periodically. Accountability also entails an obligation for operators to retain flight logs and operational data for a specified period, enabling investigations to rely on available evidence should an incident occur. On the other hand, regulatory authorities must possess the mandate to inspect operator compliance against existing provisions and impose firm sanctions for violations. Proportionate sanctions, ranging from administrative warnings to permit revocations and substantial fines, are necessary to create a sufficient deterrent effect. Furthermore, accountability requires operators to maintain liability insurance covering risks of damage or injury caused by drones, enabling victims to obtain compensation without enduring prolonged and costly litigation.

The precautionary principle provides the foundation for preventive action in drone regulation, considering that this technology is advancing rapidly while its long-term impacts remain fully unknown. This principle requires policymakers to act preventively despite scientific uncertainty surrounding specific risks, as waiting for definitive proof often means action arrives too late after damage has already occurred. In drone regulation, precaution means that new technologies should not be deployed en masse without adequate testing regarding their safety and social impacts (Rauhala et al., 2023). For instance, introducing autonomous drones or Beyond Visual Line of Sight (BVLOS) operations must be conducted incrementally under strict monitoring, rather than all at once without constraints. Precaution also dictates that privacy protection must be built into drone design from the outset, rather than tacked on after violations take place. The privacy by design approach advocated in various international instruments requires drone manufacturers to integrate privacy-preserving features, such as automated face-blurring capabilities or camera resolution caps in specific zones. By applying the

precautionary principle, drone regulation can anticipate risks before they materialize, ensuring public protection does not depend on reactive measures following harmful incidents.

The principle of respect for human rights functions as a broader normative framework for drone regulation, as privacy and freedom of movement are fundamental rights protected by constitutions and international instruments. The use of drones in public spaces must not compromise these basic rights, and any restrictions imposed must be grounded in law, serve a legitimate purpose, and remain proportionate to that purpose. This principle demands that drone regulations explicitly recognize individual privacy rights and afford effective protection against potential infringements. In this context, data collection via drones must meet the same standards as data collection through other means: it must be conducted lawfully, fairly, and transparently, with the data subject's consent or under a clear statutory legal basis. The deployment of drones by law enforcement for surveillance must be subject to independent judicial oversight and must never be used to intimidate citizens or stifle public criticism. Human rights protections also encompass the right to object and seek redress when rights are violated, requiring dispute resolution and grievance mechanisms to be available and readily accessible to the public. By embedding human rights as a core principle, drone regulations will not lose their human-centric orientation amidst rapid technological advances.

The principle of personal data protection is highly relevant because drones are frequently equipped with cameras and sensors capable of collecting highly detailed information about individuals. Concerns regarding the misuse of personal data—including individual identities, preferences, and behaviors—are escalating, given that such data can be exploited for manipulation, fraud, or even discrimination (Issalillah & Hardyansah, 2024). Responsive drone regulation must integrate established data protection principles, such as data minimization, purpose limitation, and data security. Data minimization dictates that drones may only collect data strictly necessary for operational purposes and must not gather excessive data for unrelated interests (Bassi, 2020). Purpose limitation means that collected data can only be used for explicitly declared and approved purposes, prohibiting reuse for other ends without fresh consent. Data security requires drone operators to safeguard collected data against unauthorized access, leaks, or loss through encryption and other technical measures. As stipulated under Regulation (EU) 2016/679 (General Data Protection Regulation), any processing of personal data must rest on a clear legal basis, and data subjects must be adequately informed about such processing. These principles provide robust protection against the misuse of drone-collected data, ensuring individuals retain control over their personal information even when gathered from the air.

The non-discrimination principle demands that drone regulations do not impose unfair burdens on specific social groups or create unequal access to technology. Regulations that are overly expensive or complex can prevent small and medium enterprises from utilizing drone technology, while large corporations with abundant resources can easily fulfill

compliance requirements. This dynamic creates competitive unfairness and reduces market diversity within the drone sector. Therefore, regulations must be designed considering the capacities of diverse user categories for instance, by offering lighter requirements for recreational users and micro-enterprises while maintaining stricter obligations for large-scale commercial operators. Non-discrimination also entails that regulations must not enforce disproportionate restrictions on specific groups based on irrelevant criteria, such as geographic location or socioeconomic status. Access to drone technology should be broadened as much as possible, provided reasonable safety and privacy standards are met, allowing the economic and social benefits of the technology to be enjoyed across all segments of society. By applying the non-discrimination principle, drone regulation can foster inclusivity and equity within this rapidly growing technological ecosystem.

The principle of harmonization is vital because drone usage frequently crosses administrative boundaries and distinct legal jurisdictions. Divergent regulations across regions or countries generate confusion for operators and impede effective law enforcement. Consequently, harmonizing drone regulations at both national and international levels is essential to create legal certainty and facilitate an integrated drone industry (Kandee et al., 2022). Nationally, harmonization requires regulatory consistency across ministries and local governments to eliminate confusing overlaps or contradictions. Internationally, harmonization means Indonesia should adopt best practices and standards developed by bodies such as the International Civil Aviation Organization (ICAO), while engaging in bilateral cooperation with neighboring states to manage cross-border drone flights. Harmonization does not imply eliminating all regional differences as each state maintains unique conditions and interests but it requires establishing baseline consensus on core principles and minimum procedural standards. Through harmonization, drone operators can act with greater certainty and enforcement officers can execute their duties effectively, resulting in consistent public protection across territories.

The principle of effective enforcement demands that drone regulations be backed by oversight and sanctioning mechanisms that are genuinely implementable and produce a strong deterrent effect. Even after regulations are established, compliance may remain inconsistent due to a lack of institutional capacity and infrastructure to strictly enforce data protection measures. Regulation without enforcement is merely a collection of words lacking the power to alter behavior. Effective enforcement necessitates investing in drone detection technologies such as remote identification systems and surveillance sensors so violations can be detected in real time. Law enforcement personnel must be equipped with adequate training and tools to handle drone-related cases, including capabilities to seize and analyze digital evidence. Judicial proceedings must be streamlined to ensure sanctions are imposed swiftly post-violation, as delays erode deterrence and prejudice victims. Imposed sanctions must be proportionate to the degree of fault and harm caused,

ranging from administrative fines for minor infractions to license revocations and criminal imprisonment for severe offenses. Effective enforcement also includes public participation mechanisms, allowing citizens to easily report violations while receiving protection from retaliation. With effective enforcement, drone regulation transitions from a normative instrument into an operational framework that genuinely protects society from technological risks.

The principle of technological adaptation recognizes that drone regulations must keep pace with rapid technological evolution, as rigid rules quickly become obsolete and irrelevant. To achieve this, regulations must be designed with flexibility, allowing adjustments without requiring statutory amendments every time technology shifts. One way to maintain flexibility is through ministerial-level regulations or technical policies that can be updated faster than formal laws, alongside periodic evaluation mechanisms involving experts and stakeholders (Hartmann et al., 2024). Regulations should also be performance-oriented rather than prescriptively technical meaning they set target outcomes (such as specific safety thresholds) without mandating exact technical means, leaving manufacturers and operators room to innovate. This highlights the need for stricter regulations to ensure personal data is not abused by unauthorized parties (Gardi & Eddine, 2023). Regulatory sandbox mechanisms where emerging technologies can be tested in controlled environments before broad authorization also serve as useful instruments to accommodate innovation without sacrificing safety. Through an adaptive approach, drone regulation can remain relevant and effective despite continuous technological shifts, ensuring it does not become a barrier to beneficial innovation.

The principle of public participation emphasizes that the public must be involved in drafting and evaluating drone regulations, as they represent the primary stakeholders impacted by drone operations in public spaces. Public participation is not merely symbolic consultation, but substantive engagement in policy formulation, including establishing no-fly zones, privacy standards, and grievance mechanisms. Local communities possess contextual knowledge that central policymakers may lack, and their involvement can yield regulations better aligned with local needs and values. Participation also enhances regulatory legitimacy, as citizens are more likely to comply with rules they helped shape. Participatory mechanisms can take the form of public consultations, discussion forums, field sampling, and responsive reporting channels. Governments must also provide easily understandable information regarding drone regulations and public rights so participation can occur meaningfully. Supported by strong public participation, drone regulation will not become an elite policy imposed from above, but rather a social compact reflecting a balanced consensus among all stakeholders.

The principle of international cooperation is essential because drones do not recognize national borders, and drone-related infractions often carry cross-border dimensions. Data collected by drones may be stored on overseas servers, drones can cross borders without authorization, and criminal actors can deploy drones for illegal operations

spanning multiple jurisdictions (Ahmad, 2021). Therefore, drone regulation cannot be effective if applied solely nationally without international cooperation. International cooperation encompasses information exchange regarding violations, mutual legal assistance in investigations and prosecutions, and the harmonization of technical and procedural standards. Indonesia must actively participate in international forums addressing drone governance such as the International Civil Aviation Organization and regional summits to ensure national interests are represented and to learn from global experiences. Cooperation also extends to bilateral agreements with neighboring countries concerning border airspace management and cross-border incident handling. Without international cooperation, Indonesia's drone regulatory regime will contain numerous loopholes that irresponsible parties can exploit, leaving public protection incomplete. As noted by Boucher (2015), regulating civilian drones requires a global approach because the technology carries implications extending far beyond national borders.

Regulating drones in public spaces requires a legal framework built upon complementary and mutually reinforcing principles. The principles of proportionality, transparency, accountability, precaution, respect for human rights, personal data protection, non-discrimination, harmonization, effective enforcement, technological adaptation, public participation, and international cooperation collectively form a coherent value system for responsive and equitable drone regulation. These principles do not operate in isolation; rather, they are interconnected and frequently demand careful balancing during implementation. For instance, proportionality balances innovation interests with public protection, while public participation reinforces regulatory accountability and legitimacy. A legal framework that consistently adopts these principles will be better equipped to respond to the dynamic nature of evolving drone technology, providing the policy flexibility required for adjustments without sacrificing the fundamental values of public rights protection. However, adopting these principles alone is insufficient, as successful implementation demands political commitment, institutional capacity, and active public awareness. Without these supporting factors, drone regulatory principles will remain mere normative declarations lacking real transformative power on the ground.

CONCLUSION

The legal framework governing drone usage in public spaces in Indonesia primarily derived from Minister of Transportation Regulation No. PM 90 of 2020 still suffers from fundamental weaknesses as it is oriented almost exclusively toward aviation safety while ignoring public privacy and security protection. This regulation does not explicitly govern visual data recording by drones, restrictions on personal data collection, civil liability for accidents, or grievance mechanisms for citizens who feel their rights have been infringed. Law enforcement faces severe barriers due to the absence of remote identification systems, limited detection equipment, and jurisdictional overlaps among government agencies. The public lacks adequate access to justice when victimized by drone violations, while infractions persist without meaningful consequences due to lenient sanctions and

protracted judicial proceedings. To overcome these deficiencies, drone regulation requires a foundation of legally sound principles that are responsive to technology, including proportionality, transparency, accountability, precaution, respect for human rights, personal data protection, non-discrimination, harmonization, effective enforcement, technological adaptation, public participation, and international cooperation. These principles provide a normative baseline for balanced governance between innovation interests and public protection. Without reforming the legal framework to integrate these principles, drone regulation in Indonesia will remain an ineffective and inequitable instrument, leaving the public continuously disadvantaged by uncontrolled technology.

The government needs to allocate budgetary resources toward procuring drone detection technology and training law enforcement personnel including the police and aviation officials to identify and handle drone-related offenses. Aviation regulatory bodies obtain guidance to develop effective drone registration systems and technology-based violation detection mechanisms. Law enforcement officials acquire an evaluation framework for handling drone infraction practices, while commercial actors in the drone sector understand that regulatory compliance extends beyond technical aspects to include the protection of public rights. Civil society can utilize the principles formulated in this research as an advocacy tool to demand more transparent and accountable drone policies. Furthermore, this study paves the way for cross-disciplinary collaboration among legal studies, aeronautical engineering, and technology ethics to formulate solutions for increasingly complex regulatory challenges.

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