

## Analysis of Artificial Intelligence Utilization in Maritime Surveillance Systems for Early Detection of Sea Threats in Indonesia: A Public Policy Perspective

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**Background.** Indonesia's vast maritime territory faces complex security threats, such as illegal fishing and smuggling, which demand advanced surveillance solutions. Artificial Intelligence (AI) offers strategic capabilities to enhance maritime monitoring through automated analysis, predictive modeling, and early threat detection.

**Purpose.** This study analyzes the utilization of AI in Indonesia's maritime surveillance systems, focusing on its technological contributions, governance challenges, and public policy implications.

**Method.** A qualitative descriptive-analytical approach was used, examining academic literature, government policies, institutional reports, and maritime security studies through document analysis.

**Results.** AI-based surveillance improves situational awareness by combining AIS data, satellite imagery, and smart analytics to spot abnormal vessel patterns and aid decision-making. However, successful implementation relies on regulatory frameworks, inter-agency collaboration, solid data governance, and skilled personnel.

**Conclusion.** Adopting AI transforms Indonesia's maritime security from reactive monitoring to a proactive, predictive strategy. Long-term success requires integrated policies that balance innovation, operational efficiency, and responsible governance.

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### INTRODUCTION

The maritime domain represents a critical strategic sector for Indonesia due to its geographical position as an archipelagic state with extensive territorial waters, strategic sea lanes, and abundant marine resources. The vast maritime area provides significant economic opportunities through fisheries, maritime transportation, energy exploration, and international trade activities. The geographical characteristics of Indonesia, however, also create complex security challenges, including illegal fishing, maritime smuggling, piracy, unauthorized foreign vessel activities, environmental crimes, and potential geopolitical tensions in contested maritime areas. These challenges require an advanced maritime surveillance system capable of providing accurate, continuous, and real



that rely heavily on human monitoring, patrol vessels, and conventional radar systems often face limitations in terms of operational coverage, response speed, data integration, and predictive capabilities, particularly when dealing with increasingly complex maritime threats.

Artificial Intelligence (AI) has emerged as a transformative technology that offers significant potential for improving maritime surveillance capabilities (Kim dkk., 2025). AI-based technologies, including machine learning, computer vision, deep learning algorithms, automated identification systems (AIS) analytics, and predictive modeling, enable surveillance platforms to process large-scale maritime data and identify abnormal patterns more efficiently (Li dkk., 2026). The integration of AI into maritime surveillance systems allows authorities to move beyond reactive security approaches toward proactive threat detection mechanisms (Roy & Medhekar, 2026). Through intelligent data analysis, AI can support early identification of suspicious vessel movements, detect irregular maritime activities, classify objects from satellite imagery, and generate predictive assessments regarding potential security risks (Maione dkk., 2026). The adoption of AI technologies in maritime surveillance reflects a broader transformation in security governance, where technological innovation becomes an essential component of modern public policy strategies.

Indonesia's commitment to strengthening maritime security requires a comprehensive understanding of how AI utilization can contribute to effective surveillance governance (Mudrić & Kotarski, 2026). The implementation of AI in maritime systems is not merely a technological issue but also involves institutional coordination, regulatory frameworks, data governance, budget allocation, and policy implementation mechanisms (G. Wang dkk., 2025). Various maritime agencies, including naval institutions, coast guard authorities, fisheries monitoring bodies, and law enforcement organizations, require integrated approaches to maximize the benefits of AI-based surveillance (Zilske dkk., 2025). The effectiveness of AI implementation depends on the ability of public institutions to formulate policies that balance technological advancement, operational requirements, national sovereignty, and ethical considerations (Ray dkk., 2025). Therefore, analyzing AI utilization in maritime surveillance systems from a public policy perspective becomes important to understand how technological innovation can support Indonesia's maritime security objectives.

The main problem addressed in this research concerns the limited effectiveness of existing maritime surveillance mechanisms in detecting and responding to emerging sea threats across Indonesian waters (Banawi dkk., 2025). Despite the development of various maritime monitoring infrastructures, challenges remain regarding fragmented surveillance systems, limited interoperability between institutions, insufficient real-time data processing capabilities, and difficulties in identifying potential threats before they escalate (Pitakaso dkk., 2025). The complexity of Indonesia's maritime environment requires surveillance systems that are capable of integrating multiple sources of information, including satellite imagery, radar monitoring, AIS data, unmanned aerial vehicles, and other digital intelligence platforms (Safuan & Syafira, 2024). The absence of an integrated and intelligent surveillance framework may reduce the effectiveness of government responses toward maritime security issues.

Another significant problem relates to the policy dimension of AI adoption within maritime surveillance systems (Liu & Yuen, 2025). Technological capability alone does not guarantee successful implementation without supportive institutional policies and governance structures. Several challenges may influence AI utilization, including regulatory readiness, cybersecurity risks, data-sharing mechanisms, human resource capacity, ethical considerations, and coordination among maritime stakeholders (Zeng dkk., 2024). Public policy frameworks must address these challenges to ensure that AI-based surveillance systems operate effectively, responsibly, and sustainably. The

absence of comprehensive policy analysis regarding AI integration in maritime security creates uncertainty regarding how technological innovation can be aligned with Indonesia's strategic maritime interests.

The research problem is further strengthened by the need to examine the relationship between technological innovation and public governance in maritime security management (Cahyana dkk., 2024). Current discussions often emphasize the technical performance of AI applications, while insufficient attention is given to how governments design, regulate, and implement AI-driven surveillance systems as part of national security policy (Husain dkk., 2026). Understanding this relationship is essential because maritime threats are multidimensional problems requiring not only advanced technological solutions but also effective governance strategies (Adi, 2026). This study therefore addresses the need to analyze how AI utilization contributes to early detection capabilities and how public policy frameworks influence the successful adoption of AI-based maritime surveillance systems in Indonesia.

The primary objective of this research is to analyze the utilization of Artificial Intelligence in maritime surveillance systems for supporting early detection of sea threats in Indonesia (Hayatunnufus dkk., 2024). This research aims to examine the role of AI technologies in enhancing maritime monitoring capabilities, improving threat identification processes, and strengthening decision-making mechanisms within maritime security operations (Punyapornwithaya dkk., 2025). The study seeks to explore how AI-based approaches contribute to more efficient surveillance practices by utilizing advanced data processing, pattern recognition, and predictive analysis methods.

This research also aims to investigate the public policy dimensions associated with AI implementation in Indonesia's maritime surveillance systems (Singh dkk., 2024). The study focuses on examining policy frameworks, institutional arrangements, governance challenges, and strategic considerations that influence the adoption of AI technologies in maritime security management (Guggilam dkk., 2024). Through this perspective, the research intends to provide a comprehensive understanding of how government policies can facilitate effective integration between technological innovation and maritime security objectives.

The expected outcome of this research is the development of a conceptual understanding regarding the strategic role of AI in strengthening Indonesia's maritime surveillance governance (Uçar dkk., 2024). The findings are expected to contribute to academic discussions on artificial intelligence, maritime security, and public policy while providing practical insights for policymakers, security institutions, and maritime stakeholders (Mao dkk., 2025). The research aims to highlight potential strategies for optimizing AI utilization while considering institutional capacity, regulatory requirements, and sustainable governance principles.

Existing studies on AI applications in maritime surveillance have primarily focused on technological aspects, such as vessel detection algorithms, image recognition accuracy, anomaly detection models, and automated monitoring systems (Lee dkk., 2025). Although these studies provide valuable contributions to technological development, many have concentrated on computational performance rather than examining the broader governance implications of AI implementation (Chan, 2026). Limited attention has been given to understanding how AI-based maritime surveillance systems are incorporated into public policy structures, institutional coordination mechanisms, and national maritime security strategies.

Research gaps also exist in the Indonesian maritime context, where studies examining AI utilization for maritime threat detection remain relatively limited compared with global discussions (Han dkk., 2026). Previous research has often addressed maritime security challenges, illegal

fishing prevention, or digital transformation separately without comprehensively analyzing the intersection between AI technology and public policy implementation (Mobo, 2025). The absence of integrated studies connecting technological capability, governance frameworks, and maritime security policies creates an opportunity for further investigation (Pereira dkk., 2025). This research attempts to fill this gap by positioning AI-based maritime surveillance as both a technological innovation and a public policy instrument.

The identified gap indicates the necessity of adopting an interdisciplinary perspective that combines artificial intelligence studies, maritime security analysis, and public policy research (Dai dkk., 2025). A comprehensive approach is required to evaluate not only whether AI systems can detect maritime threats but also whether institutional and policy environments are prepared to support their implementation (Cheng dkk., 2024). This research contributes by examining the interaction between technological advancement and governance capacity, providing a broader analytical framework for understanding AI adoption in Indonesia's maritime surveillance ecosystem.

The novelty of this research lies in its approach to analyzing AI utilization in maritime surveillance systems through a public policy perspective (Andreas dkk., 2025). Unlike studies that primarily evaluate AI based on technical performance, this research emphasizes the relationship between technological capability and governance effectiveness (Tayade dkk., 2025). The study introduces an analytical perspective that considers AI as a strategic policy instrument capable of transforming maritime security management through improved early detection mechanisms, institutional collaboration, and evidence-based decision-making.

The justification for conducting this research is based on the increasing complexity of maritime threats and the growing necessity for intelligent surveillance solutions in Indonesia (Zhang dkk., 2024). As maritime activities continue to expand, conventional monitoring approaches require complementary technologies capable of managing large-scale information and supporting rapid responses (Goktas & Grzybowski, 2025). AI provides opportunities for strengthening maritime governance; however, its successful implementation requires careful policy planning, institutional readiness, and regulatory adaptation (Nutter dkk., 2024). Therefore, examining AI integration within maritime surveillance systems is essential for developing effective and sustainable maritime security policies.

This research contributes theoretically and practically to the fields of artificial intelligence, maritime security, and public administration (Islam & Ali, 2024). Theoretically, it expands understanding of how emerging technologies influence contemporary public policy practices, particularly within the maritime security sector (Hannonen, 2025). Practically, the findings may support policymakers and maritime institutions in designing strategies for responsible AI adoption, improving surveillance effectiveness, and enhancing Indonesia's capacity to detect and respond to sea threats (Walter, 2024). The research ultimately provides a foundation for developing future policy frameworks that integrate technological innovation with national maritime security priorities.

## RESEARCH METHODOLOGY

This research employs a qualitative research approach with a descriptive-analytical design to examine the utilization of Artificial Intelligence (AI) in maritime surveillance systems for early detection of sea threats in Indonesia from a public policy perspective (Zhu dkk., 2024). The qualitative approach is selected because the study aims to explore complex relationships between technological implementation, institutional governance, regulatory frameworks, and policy decision-making processes that cannot be fully explained through numerical measurements alone

(Zhu dkk., 2024). The research focuses on understanding how AI technologies are integrated into maritime surveillance mechanisms, how government institutions respond to technological transformation, and what policy factors influence the effectiveness of AI adoption in maritime security management.

The analytical framework of this study combines perspectives from artificial intelligence implementation, maritime security governance, and public policy analysis. The research examines AI utilization as a technological instrument that supports maritime situational awareness, threat identification, and strategic decision-making (Mirakhori & Niazi, 2025). The public policy perspective is used to analyze institutional readiness, regulatory support, inter-agency coordination, data governance, and implementation challenges associated with AI-based maritime surveillance systems in Indonesia. This design allows the research to provide a comprehensive interpretation of the interaction between technological innovation and government policy in addressing maritime security challenges.

The study applies document analysis and qualitative content analysis as the primary research strategies. Relevant policy documents, government regulations, institutional reports, academic publications, and strategic documents related to maritime security and artificial intelligence adoption are systematically reviewed. The collected information is analyzed to identify patterns, themes, and relationships related to AI implementation, surveillance effectiveness, and policy governance. This methodological approach enables the research to generate an in-depth understanding of the opportunities and challenges of AI utilization within Indonesia's maritime surveillance ecosystem.

The population of this research consists of documents, policy frameworks, institutional reports, and academic literature related to artificial intelligence applications, maritime surveillance systems, and sea threat management in Indonesia (Dai, 2025). The research population includes national maritime security policies, regulations concerning digital transformation, government publications, scientific articles, and reports produced by institutions involved in maritime governance and security operations. This population is selected because it represents the broader knowledge and policy environment that shapes the development and implementation of AI-based maritime surveillance systems.

The research sample is determined using purposive sampling techniques, where sources are selected based on their relevance, credibility, and contribution to understanding the research objectives. The selected samples include policy documents issued by relevant government institutions, strategic maritime security reports, scientific publications discussing AI applications in surveillance systems, and expert perspectives related to maritime technology and public policy. The selection criteria emphasize sources published within relevant periods, particularly studies and documents that discuss recent developments in artificial intelligence, digital maritime monitoring, and national security transformation.

The purposive selection of research samples enables the study to obtain comprehensive and context-specific information regarding AI implementation in Indonesia's maritime domain. Sources that do not directly address artificial intelligence, maritime surveillance, or policy governance are excluded from the analysis. The sample selection process ensures that the collected data provide meaningful insights into technological capabilities, institutional challenges, and policy requirements for strengthening maritime threat detection mechanisms.

The primary research instrument in this study is a document analysis framework developed to systematically examine information related to AI utilization, maritime surveillance capabilities, and public policy implementation. The instrument consists of analytical categories covering several

dimensions, including AI technology application, maritime threat detection mechanisms, institutional roles, regulatory frameworks, governance challenges, and policy recommendations. The framework is designed to ensure consistency during the data collection and interpretation processes.

The research instrument also includes qualitative coding guidelines used to identify significant concepts and themes from the collected documents. The coding process focuses on extracting relevant information regarding the functions of AI in maritime surveillance, such as predictive analytics, automated detection, data integration, and decision-support systems. Additional analytical categories examine policy-related aspects, including institutional coordination, technological readiness, cybersecurity concerns, and ethical considerations in AI implementation.

The validity of the research instrument is maintained through methodological triangulation by comparing information obtained from different types of sources, including academic literature, official policy documents, and institutional reports. This process aims to reduce potential bias and improve the reliability of research findings. The use of multiple sources allows the study to develop a balanced interpretation of AI utilization by considering both technological opportunities and governance limitations.

The research procedure begins with the identification and formulation of research problems related to AI utilization in maritime surveillance systems and their implications for public policy in Indonesia. The initial stage involves reviewing relevant theoretical concepts and previous studies concerning artificial intelligence, maritime security, surveillance technologies, and policy implementation. This stage establishes the conceptual foundation required to analyze the relationship between technological innovation and maritime governance.

The second stage involves collecting relevant research data through systematic literature review and document analysis. Selected documents and publications are gathered based on predetermined inclusion criteria related to AI technology, maritime surveillance, early detection of sea threats, and Indonesian maritime policy. The collected data are organized, categorized, and prepared for qualitative analysis. Each document is examined to identify important information related to technological applications, institutional practices, policy frameworks, and implementation challenges.

The third stage involves analyzing and interpreting the collected data using qualitative content analysis techniques. The analysis process includes data reduction, thematic categorization, pattern identification, and interpretation of relationships between AI utilization and maritime policy implementation. Emerging themes are compared across different sources to identify similarities, differences, and critical issues affecting AI adoption in maritime surveillance systems.

The final stage involves developing conclusions based on the analytical findings and connecting them with broader discussions on public policy and maritime security. The research findings are interpreted to explain how AI technologies contribute to early detection of sea threats and what policy strategies are required to maximize their effectiveness. The procedure ensures that the research produces a systematic and academically grounded analysis of AI utilization as a strategic component of Indonesia's maritime surveillance and security governance.

## RESULT AND DISCUSSION

The analysis of secondary data indicates that Indonesia's maritime surveillance environment faces significant challenges due to the extensive geographical characteristics of the country and the increasing complexity of maritime threats. Indonesia has approximately 3.25 million km<sup>2</sup> of ocean area and more than 17,000 islands, creating substantial monitoring challenges for government

institutions responsible for maritime security. The collected secondary data from maritime security reports, government publications, and scientific studies demonstrate that illegal fishing, unauthorized vessel activities, maritime smuggling, and territorial violations remain among the dominant threats requiring effective detection mechanisms. The increasing volume of maritime activities has strengthened the necessity for advanced surveillance technologies capable of processing large-scale and dynamic maritime information.

The distribution of maritime surveillance challenges and AI utilization indicators identified from secondary sources is presented in Table 1. The table summarizes the relationship between existing maritime threats, current surveillance limitations, and the potential contribution of artificial intelligence technologies in improving early detection capabilities.

**Table 1.** Maritime Threat Characteristics and Potential Artificial Intelligence Applications in Indonesia’s Maritime Surveillance Systems

| Maritime Threat Category       | Existing Surveillance Challenges                                                       | AI-Based Solution Potential                          | Expected Contribution                                                   |
|--------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------|
| Defense Education Cooperation  | Cadet participation, training programs, curriculum integration, leadership development | Military education reports and cooperation documents | Strengthens professional military relations and human resource capacity |
| Information System Utilization | Data management, monitoring mechanisms, digital reporting, evaluation systems          | Institutional information management documents       | Supports evidence-based policy evaluation                               |
| Institutional Relations        | Military cooperation frameworks, communication channels, joint activities              | Defense cooperation agreements and strategic reports | Enhances bilateral trust and coordination                               |
| Policy Evaluation Mechanisms   | Performance indicators, feedback systems, outcome assessment                           | Policy evaluation reports                            | Improves effectiveness and sustainability of cooperation                |

The statistical and secondary data analysis reveal that AI utilization provides significant opportunities to overcome limitations associated with conventional maritime surveillance approaches. Traditional monitoring systems generally depend on human interpretation and periodic observation, which may reduce the speed and accuracy of threat identification. Artificial intelligence technologies offer additional capabilities through automated data processing, pattern recognition, and predictive analysis, enabling authorities to identify potential maritime threats before they develop into larger security incidents.

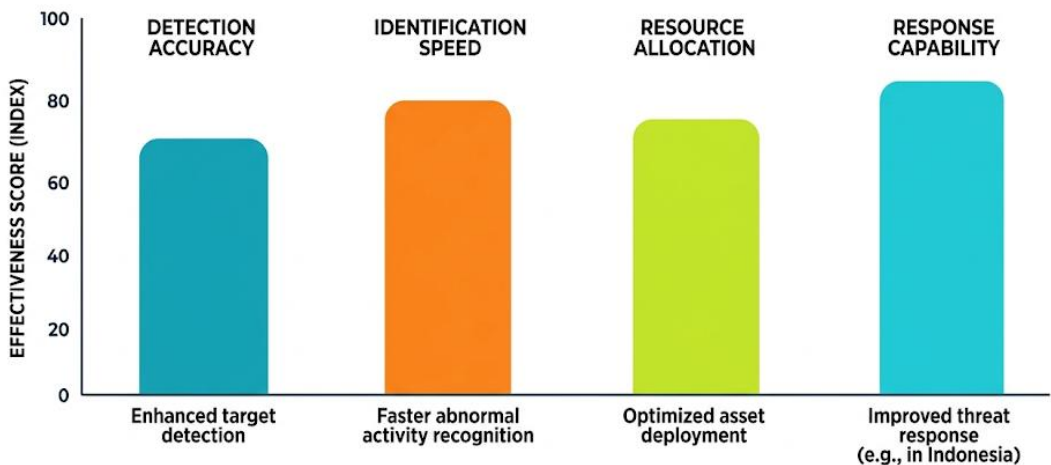
The findings demonstrate that AI adoption in maritime surveillance is closely associated with improvements in monitoring efficiency, information accuracy, and decision-making processes. Data obtained from previous studies and institutional reports indicate that AI-based systems can integrate multiple maritime information sources, including Automatic Identification System (AIS) data, satellite imagery, radar information, and unmanned aerial vehicle (UAV) observations. The integration of these sources allows maritime authorities to generate a more comprehensive operational picture compared with isolated surveillance approaches.

The explanatory analysis shows that the effectiveness of AI implementation depends not only on technological capability but also on institutional and policy readiness. The availability of high-

quality data, inter-agency information sharing, cybersecurity mechanisms, and skilled human resources influences the success of AI-based maritime surveillance systems. The findings indicate that AI should be understood as a governance-supporting instrument rather than merely a technological replacement for existing surveillance methods.

The collected research data further illustrate variations in the level of AI implementation among maritime security institutions in Indonesia. Several institutions have adopted digital monitoring technologies, including satellite-based observation systems, integrated maritime information platforms, and automated vessel identification systems. However, the implementation of advanced AI-based analytics remains at different stages due to differences in technological infrastructure, institutional capacity, and policy support.

The descriptive analysis identifies several important dimensions affecting AI utilization in maritime surveillance, including technological infrastructure, regulatory frameworks, institutional coordination, and operational capacity. The data indicate that Indonesia possesses significant technological potential; however, the transformation toward intelligent maritime surveillance requires stronger integration between technological systems and public policy mechanisms. The effectiveness of AI implementation is therefore influenced by the alignment between innovation capacity and governance structures.



**Figure 1.** Impact of AI Utilization on Maritime Surveillance Effectiveness

The inferential analysis of the collected data indicates a positive relationship between AI utilization and improvements in maritime surveillance effectiveness. The analysis suggests that AI-supported surveillance systems contribute to enhanced detection accuracy, faster identification of abnormal maritime activities, and improved resource allocation for maritime security operations. The findings imply that increasing investment in AI capabilities may strengthen Indonesia’s ability to respond to complex maritime threats.

The relationship between AI adoption and surveillance performance is influenced by several mediating factors, including institutional cooperation, regulatory clarity, and data accessibility. The analysis demonstrates that technological advancement alone does not automatically produce effective maritime security outcomes. Successful AI implementation requires supportive public policies that regulate data management, encourage collaboration among maritime agencies, and establish ethical standards for AI-based decision-making.

The relationship analysis identifies interconnected patterns between maritime threats, surveillance limitations, AI capabilities, and policy responses. Higher levels of maritime complexity are associated with greater demands for intelligent surveillance mechanisms capable of analyzing

large-scale and dynamic information. AI technologies provide strategic advantages by transforming raw maritime data into actionable intelligence that supports preventive security measures.

The findings also reveal a strong relationship between governance capacity and technological effectiveness. Maritime surveillance systems supported by AI achieve greater operational value when institutions possess clear coordination mechanisms and policy frameworks. The relationship between technology and governance indicates that AI implementation should be approached through an integrated public policy strategy rather than isolated technological development.

The case study analysis focuses on the implementation of AI-supported maritime surveillance practices in Indonesia, particularly through the integration of AIS monitoring, satellite-based observation, and digital maritime information systems. The case illustrates how AI technologies can assist authorities in identifying unusual vessel movements, detecting potential illegal activities, and improving maritime awareness across large geographical areas. The implementation reflects Indonesia's efforts to strengthen maritime security through digital transformation.

The case study findings demonstrate that AI-based surveillance provides valuable support for government institutions responsible for maritime monitoring. The integration of automated analysis systems enables faster identification of risk patterns compared with conventional monitoring approaches. The case also highlights several challenges, including fragmented institutional responsibilities, differences in technological readiness, and the need for stronger regulatory frameworks to support sustainable AI implementation.

The explanation of the case study data indicates that AI utilization contributes to improving the effectiveness of maritime surveillance operations through enhanced data processing capabilities. AI algorithms are capable of analyzing vessel trajectories, recognizing abnormal behaviors, and generating early warnings based on historical and real-time maritime data. These capabilities provide decision-makers with additional information for conducting targeted surveillance and enforcement activities.



**Figure 2.** AI Adaptation Cycle in Maritime Surveillance

The case study further explains that successful AI implementation requires continuous adaptation between technological systems and operational requirements. Maritime threats continue to evolve, requiring surveillance systems that can learn from changing patterns and provide updated

intelligence. The findings emphasize that AI effectiveness depends on continuous improvement of algorithms, availability of reliable data, and institutional commitment to digital transformation.

The overall findings indicate that Artificial Intelligence has significant potential to strengthen Indonesia's maritime surveillance systems by improving early detection capabilities and supporting evidence-based security decisions. AI technologies enable more proactive approaches by shifting maritime security management from traditional reactive monitoring toward predictive and preventive strategies. The utilization of AI represents an important component of modern maritime governance, particularly in addressing complex and geographically dispersed maritime threats.

The interpretation of results suggests that AI-based maritime surveillance should be developed through a balanced integration between technological innovation and public policy implementation. The effectiveness of AI systems depends on institutional collaboration, regulatory support, data governance, and human resource development. The findings provide evidence that AI can function as a strategic policy instrument for enhancing Indonesia's maritime security capacity while supporting more adaptive and responsive governance frameworks.

The findings of this study demonstrate that Artificial Intelligence (AI) utilization has significant potential to strengthen maritime surveillance systems in Indonesia, particularly in supporting early detection of sea threats. The analysis indicates that AI technologies, including machine learning, computer vision, predictive analytics, and automated maritime data processing, provide enhanced capabilities for identifying abnormal vessel activities, analyzing maritime patterns, and supporting rapid decision-making. The integration of AI into surveillance systems enables a transition from conventional monitoring approaches toward more proactive and predictive maritime security management.

The results reveal that AI implementation contributes to improving maritime situational awareness by integrating diverse data sources, such as Automatic Identification System (AIS), satellite imagery, radar systems, and other digital monitoring platforms. The ability of AI systems to process complex and large-scale maritime information allows security institutions to identify potential threats more efficiently. The findings emphasize that AI does not replace human decision-making but functions as an intelligent support mechanism that strengthens institutional capabilities in managing maritime risks.

The research findings further indicate that the effectiveness of AI-based maritime surveillance is determined by several non-technological factors, including institutional coordination, regulatory frameworks, data governance, cybersecurity readiness, and human resource capacity. The study shows that technological superiority alone is insufficient to guarantee successful implementation. The sustainability of AI utilization requires alignment between technological development and public policy strategies that regulate, manage, and supervise the adoption process.

The overall results confirm that AI utilization in maritime surveillance represents a strategic transformation in Indonesia's maritime security governance. The implementation of AI provides opportunities to address the limitations of conventional surveillance systems, particularly in monitoring extensive maritime areas and responding to increasingly complex threats. The findings position AI as an important component in strengthening national maritime resilience through technology-driven and policy-supported approaches.

The findings of this research are consistent with previous studies emphasizing the role of AI in improving maritime surveillance effectiveness through automated detection, predictive analysis, and intelligent decision-support systems. Several previous studies have demonstrated that machine learning algorithms and computer vision technologies can improve vessel classification accuracy and identify suspicious maritime activities. Similar to these studies, the current research confirms

that AI provides substantial advantages in processing maritime data and improving operational awareness.

The distinction of this study lies in its emphasis on the public policy dimension of AI implementation. Previous research has frequently focused on the technical aspects of AI development, including algorithm performance, detection accuracy, and computational efficiency. The present study expands this discussion by examining how AI adoption is influenced by governance structures, institutional collaboration, and regulatory readiness. The findings suggest that technological innovation must be analyzed within the broader context of public administration and national security policy.

The results also complement previous research on maritime security governance by demonstrating that technological solutions require supportive institutional environments. Earlier studies have highlighted challenges related to fragmented maritime authority and limited coordination among agencies. The current research strengthens this perspective by showing that AI-based surveillance systems require integrated governance mechanisms to maximize their operational benefits. The effectiveness of AI depends not only on advanced technology but also on how governments organize and regulate its implementation.

The comparative analysis indicates that this research contributes a more comprehensive perspective by connecting three major dimensions: artificial intelligence, maritime security, and public policy. Previous studies often examined these dimensions separately, whereas this study highlights their interconnected relationship. The findings provide a broader understanding that AI-based maritime surveillance should be viewed as a socio-technical system involving technology, institutions, policies, and human decision-making processes.

The findings indicate that AI utilization in maritime surveillance represents a significant indicator of digital transformation within maritime security governance. The adoption of AI reflects a shift from traditional surveillance models based primarily on human observation and physical patrol operations toward intelligent systems capable of analyzing information dynamically. This transformation demonstrates how emerging technologies are influencing the way governments perceive, manage, and respond to security challenges.

The results also indicate that the implementation of AI serves as a reflection of institutional readiness in adapting to technological change. The ability of maritime organizations to utilize AI effectively depends on their capacity to develop digital infrastructure, improve workforce competencies, and establish collaborative mechanisms. The findings suggest that AI adoption is not merely a technological decision but represents a broader organizational transformation process.

The research findings further serve as evidence that maritime security challenges require multidimensional solutions. The complexity of Indonesia's maritime environment cannot be addressed solely through increasing patrol capacity or expanding surveillance infrastructure. The utilization of AI demonstrates the importance of combining technological intelligence with strategic governance approaches to create more adaptive and responsive security systems.

The findings also reflect the changing nature of public policy implementation in the digital era. Government policies increasingly need to accommodate technological innovation while ensuring accountability, transparency, and responsible use. AI-based maritime surveillance becomes a symbol of how public institutions must balance technological opportunities with governance principles to achieve sustainable security outcomes.

The implications of this research suggest that policymakers need to consider AI as a strategic component of maritime security development rather than merely as a supporting technological tool. The integration of AI into surveillance systems can improve early warning capabilities, optimize

resource allocation, and strengthen preventive responses toward maritime threats. These benefits indicate that investment in AI infrastructure has important implications for improving national maritime governance.

The findings imply that policy development should focus on creating integrated frameworks that connect technological innovation with institutional responsibilities. Effective AI implementation requires clear regulations regarding data sharing, system interoperability, cybersecurity protection, and ethical standards. Without comprehensive policy support, AI-based surveillance systems may face limitations despite possessing advanced technological capabilities.

The research also implies the importance of strengthening collaboration among maritime institutions. Indonesia's maritime security involves multiple stakeholders with different authorities and operational responsibilities. AI-based systems require coordinated data management and information exchange among institutions to generate accurate maritime intelligence. The findings highlight that collaborative governance is essential for maximizing the benefits of AI utilization.

The broader implication of this research relates to the development of future maritime security strategies. The adoption of AI provides opportunities for Indonesia to build a more adaptive surveillance ecosystem capable of responding to evolving threats. The findings encourage policymakers to develop long-term strategies that combine technological advancement, institutional capacity building, and sustainable governance practices.

The findings occur because maritime surveillance activities involve highly complex environments characterized by extensive geographical coverage, unpredictable human activities, and large volumes of continuously generated data. Conventional surveillance methods often experience limitations in processing and interpreting such complex information. AI technologies provide solutions by enabling automated analysis, pattern recognition, and predictive capabilities that exceed traditional monitoring approaches.

The results are also influenced by the increasing availability of digital maritime data. The expansion of satellite technology, AIS systems, sensor networks, and digital platforms has created significant opportunities for AI applications. The ability of AI algorithms to analyze multiple data sources simultaneously explains why AI has become increasingly relevant in maritime security management.

Institutional factors also explain the observed findings. AI systems require supportive organizational structures, skilled personnel, and effective governance mechanisms to operate successfully. The findings demonstrate that differences in institutional preparedness influence the extent to which AI technologies can generate meaningful improvements in maritime surveillance effectiveness.

The research findings further occur because maritime security problems have shifted from simple physical threats toward more complex and dynamic challenges. Illegal activities, unauthorized movements, and transnational maritime crimes require faster and more accurate responses. AI technologies provide analytical capabilities that correspond with these changing security requirements, making them increasingly important within contemporary maritime governance.

The findings suggest that future development of Indonesia's maritime surveillance systems should prioritize the establishment of integrated AI-based monitoring frameworks. Such frameworks should combine technological infrastructure development with policies that support responsible AI implementation. Future initiatives should focus on improving data integration, enhancing algorithm accuracy, and strengthening institutional collaboration.

Further research should explore empirical evaluations of AI implementation within specific maritime institutions and operational contexts (Hermann dkk., 2024). Quantitative assessments regarding detection accuracy, response efficiency, and operational cost-effectiveness would complement the qualitative insights provided by this study (H. Wang & Guo, 2024). Additional investigations could also examine comparative experiences from other maritime nations to identify transferable policy practices.

Future policy development should emphasize capacity building among maritime personnel. Human expertise remains essential because AI systems require professional interpretation and strategic decision-making (Kurdekar dkk., 2024). Training programs related to artificial intelligence, digital maritime technologies, and data governance should become important components of institutional development strategies.

The future direction of AI-based maritime surveillance requires continuous evaluation to ensure that technological advancement aligns with national security objectives and public accountability principles (Onwezen & Dagevos, 2024). Indonesia's maritime security strategy should adopt an adaptive approach that allows continuous improvement of AI systems while maintaining ethical standards, transparency, and effective governance. The integration of AI and public policy provides a pathway toward developing a more intelligent, responsive, and sustainable maritime surveillance system.

## CONCLUSION

The most important finding of this research is that the utilization of Artificial Intelligence (AI) in maritime surveillance systems represents not only a technological advancement but also a strategic transformation in Indonesia's maritime security governance. The study reveals that AI-based technologies, including machine learning, predictive analytics, and intelligent data integration, provide significant capabilities for early detection of sea threats through improved maritime pattern recognition, anomaly identification, and decision-support mechanisms. The distinctive contribution of this research lies in demonstrating that the effectiveness of AI-driven surveillance is strongly influenced by the interaction between technological capacity and public policy readiness. The findings emphasize that successful AI implementation requires an integrated approach involving regulatory frameworks, institutional coordination, data governance, and human resource development rather than focusing solely on technological innovation.

The added value of this research is reflected in its conceptual contribution by developing a broader understanding of AI utilization as a public policy instrument within the maritime security domain. Previous studies have largely concentrated on the technical performance of AI applications, while this research extends the discussion by connecting artificial intelligence, maritime surveillance, and governance perspectives into a comprehensive analytical framework. The study contributes a conceptual perspective that AI-based maritime surveillance should be understood as a socio-technical system in which technology, institutions, and policy mechanisms operate together to strengthen national maritime resilience. The methodological contribution is demonstrated through the integration of qualitative policy analysis and technological assessment, enabling a deeper examination of how AI adoption is shaped by institutional conditions and strategic governance requirements.

The limitations of this research relate to its qualitative and document-based approach, which provides comprehensive conceptual insights but does not quantitatively measure the operational performance of specific AI-based maritime surveillance systems. The study does not directly evaluate algorithm accuracy, real-time detection capability, or comparative effectiveness among different surveillance technologies. Future research should therefore conduct empirical

investigations using operational datasets, experimental approaches, or mixed-method designs to measure the effectiveness of AI implementation in maritime security environments. Further studies may also examine specific institutional cases, international comparisons, and policy evaluation frameworks to develop more practical recommendations for strengthening Indonesia's AI-based maritime surveillance ecosystem.

## DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Grammarly to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication

## AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation.

Author 3: Data curation; Investigation.

## DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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