An Integrated Maritime Fusion Governance Model: An AHP-Based Escalation Framework for Maritime Security

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ABSTRACT

Maritime security governance in archipelagic states such as Indonesia suffers from fragmented institutions, overlapping mandates, and the absence of structured escalation logic linking threat conditions to response levels. This study addresses these gaps by proposing and demonstrating the Integrated Maritime Fusion-Governance Model (IMFGM), a decision framework that combines fusion centre operations, escalation protocols, and quantitative multi-criteria analysis. Using a simulated Analytical Hierarchy Process (AHP) grounded in theoretical escalation theory and maritime operational doctrine, the model evaluates four Siaga alert states (Siaga 4 normal monitoring to Siaga 1 maximum readiness) across three primary criteria (strategic, operational, tactical) and six sub-criteria (indicators, threat trends, Common Operational Picture, coordination, intercept control, target accuracy). The results reveal that tactical utility dominates (weight = 0.63), with intercept control accounting for nearly half of the global decision priority (0.473). Under baseline assumptions, Siaga 1 ranks highest (0.46), followed by Siaga 2 (0.31), Siaga 3 (0.15), and Siaga 4 (0.08). Sensitivity analysis confirms model adaptiveness: reducing tactical weight to 0.40 makes Siaga 2 optimal, while elevating strategic weight raises Siaga 3. The study extends Bueger's maritime security assemblage framework by adding decision and escalation dimensions. Policy recommendations include establishing a national fusion centre with prioritised data hierarchies, formalising quantified escalation protocols, strengthening civil-military coordination through joint standard operating procedures, enhancing C4ISR interoperability, and conducting empirical AHP surveys for model calibration. Limitations include the use of simulated rather than empirical expert judgments and the static nature of the AHP framework. The IMFGM provides a transparent, replicable architecture for maritime escalation governance pending real-world validation.

INTRODUCTION

Oceans stretch across most of the planet - around 72 percent - and hold critical roles in how nations exchange goods, secure energy, maintain influence. In island countries like Indonesia, sea areas shape more than maps; they define who people are, how they survive, what keeps the state whole. Spread over some 17,000 islands, this nation claims waters and special rights beyond its shores totaling nearly 6.4 million square kilometers (Haryono et al., 2025), making it the biggest cluster of landmasses surrounded by ocean anywhere. Yet such rich access brings heavy burdens too. Long shorelines, congested routes - the Malacca and Lombok passages among them along with distant frontier zones face rising pressure from new kinds of dangers outside old-style warfare frameworks. Nowadays, threats at sea are harder to foresee, tangled together in ways past generations never faced. Not just one problem stands alone overfishing slips through weak oversight, draining ocean life while economies near shorelines lose massive sums each year. Food supplies shrink. Jobs vanish. Criminal networks move silently across open waters, pushing drugs, people, weapons all because island-heavy regions lack tight control over their seas(Sondakh et al., 2025). What keeps strategists awake involves actions barely visible: maneuvers too subtle for war yet sharp enough to test borders and unsettle peace. Patrol boats act aggressively. Fishermen get blocked without warning. Unlabeled ships appear doing unclear tasks. Loopholes in law help such tactics succeed, slipping between cracks of authority so force stays off the table (Octavian, 2025).

Over recent years, ideas about modern maritime safety have shifted in notable ways. Rather than seeing it as a single fixed state, scholars like Bueger and Edmunds describe it as a mix of rules, groups, and actions, that some now call maritime security governance (Bueger et al., 2025). Appearing in the International and Comparative Law Quarterly, their study shows how UNCLOS, the so-called ocean constitution - functions not alone, yet alongside many other actors shaping sea-related order. From this angle, real progress in protecting waterways depends on how U.N. bodies link with regional partnerships, country-to-country deals, and loosely formed cooperation efforts; each brings specific strengths while struggling with particular weaknesses. Bueger and others outline three ways to adjust the system: creating specialized UN maritime security units, addressing clashes at operational boundaries via focused actions, yet also turning proven unofficial practices into official rules (Bueger et al., 2025). From this wider conceptual frame, Maritime Domain Awareness takes shape - not as a trend, but as a core element in sound sea-based security management. What counts is knowing what happens at sea when it might affect safety, economic interests, ecological balance, or national protection (Haryono et al., 2025 In practice, assembling inputs like ship tracking signals, shore-mounted radar outputs, space-based imaging, aerial patrols, alongside classified findings builds one shared view used to act quickly with clarity. Though scattered, these inputs matter most when fused; for Indonesia’s naval force (TNI Angkatan Laut), sharpening this awareness means spotting risks sooner while aligning reactions faster. Still, hurdles remain even after new steps were taken by TNI AL. Radar-linked surveillance now works alongside upgraded AIS functions. Satellite images support oversight more regularly than before. Cooperation exists with local bodies and neighboring area allies. Yet mismatched systems slow coordination across platforms. Remote island zones lack strong technical foundations. Staff skills do not always match operational needs.

Among tools meant to strengthen maritime domain awareness, fusion centers now play a central role through organized collaboration. Stemming from military-originated C4ISR systems, these hubs collect inputs from varied channels. Information gets studied across different times and locations before being shared with relevant parties. According to Dolonseda (2022), , the defense sector's backing of such technological structures matters greatly for Indonesia's sea safety goals. At their best, fusion operations become core nodes in ocean management turning unprocessed signals into insights that guide choices. Coordination improves among agencies that normally work apart when one central hub shapes understanding. A key blind spot emerges when MDA meets maritime security - how conflict intensifies. Though escalation frameworks originated in nuclear and traditional warfare studies, they probe shifts from mild rivalry to open clash. Cognitive distortions, organizational strain, and uneven knowledge shape these turning points, as Brehmer showed in uncertain command settings. At sea, unclear pathways for managing rising tensions leave room for misjudgment: minor events like unauthorized fishing or aggressive monitoring might ease via talks or ignite violence based on impulsive choices. Naval power walks a fine line; it counters smuggling, piracy, and shadow tactics, but its deployment risks inflaming rival states, feeding cycles of reaction. This balancing act the need for ships versus the risk they bring is what Bueger frames as the militarization paradox (Bueger et al., 2025).

When threats rise, Indonesia shifts its readiness using four distinct stages called Siaga levels. Level 4 marks everyday operations where observation stays steady through regular checks and quiet tracking efforts. At level 3, awareness sharpens due to growing risks - agencies gather more data while improving cooperation across departments. Moving into level 2 means forces must act faster; interception abilities activate alongside tighter collaboration between military units and public authorities. Maximum alert status, known as Siaga 1, involves complete deployment of military forces and permits deadly force. Yet the current system does not define clear thresholds connecting observable threats to each response level. Without measurable benchmarks, shifts between stages rely more on personal interpretation than consistent analysis. Power dynamics within agencies often shape such choices, alongside immediate operational demands. Complicating matters, Indonesia's maritime oversight structure spreads authority across overlapping bodies. The national coast guard - officially Badan Keamanan Laut Republik Indonesia - is tasked with unifying patrols and enabling data exchange among various actors. Authority over fisheries management and anti-illegal fishing efforts lies with the Ministry of Marine Affairs and Fisheries (KKP). Oversight of shipping safety, vessel movement, and port activities falls under the Directorate General of Sea Transportation (Hubla). National defense at sea, including military reactions to maritime dangers, is controlled by TNI Angkatan Laut. Such division creates gaps where responsibilities blur, tasks repeat, communication falters - undermining high-tech MDA systems despite their capabilities. According to Sondakh et al. (2025), these overlaps weaken enforcement performance significantly. Studying Bakamla's shift toward a coast guard framework reveals structural disconnection as the main barrier. Clearer roles at strategic, operational, and field levels demand merged regulations, centralized leadership, and shared data hubs across agencies.

Despite appearing bureaucratic, Indonesia's sea-related oversight now confronts deeper geopolitical pressures. According to Octavian (2025), in the Journal of Geomaritime and Future Studies, threats at sea will grow more complex - driven by smart technologies used in hybrid attacks, worsening ecosystems due to emissions and rising temperatures, while imbalanced forces exploit unconventional methods. Through his idea of geomaritime resilience, a dual-purpose tool emerges: one that interprets trends and guides decisions by blending economic geography with long-term ocean stewardship. As major nations compete fiercely across the Indo-Pacific, Indonesia finds itself positioned within crosshairs of rivalry; minor naval tensions near its shores may quickly draw global reactions. Outside forces sharpen the need for clear, logical, and open processes when deciding how to escalate actions at home. Research on this topic has grown in separate directions - each useful on its own, yet rarely brought together. A first direction examines tools of monitoring: systems that detect threats, methods that combine information, channels that relay messages, and ways to position observation platforms efficiently. Work here shows deep technical skill, though it frequently presumes better sensing leads straight to better control - a belief weakened by scattered authority across agencies. A fresh look comes from research into sea-related governance systems laws, joint operations between agencies, partnerships across regions, plus efforts to strengthen capabilities. While these works point out scattered responsibilities and clashing roles as central issues, they tend to suggest ideas based on judgment rather than numbers or clear benchmarks. Another strand, still small when it comes to oceans, uses tools like the Analytical Hierarchy Process to weigh different security needs against one another. In a 2025 paper, Deniozos & Stamatopoulos (2025), show how blending SWOT evaluations with AHP improves choices in maritime defense planning, revealing that comparing options two at a time and using eigenvalues helps rank intangible strategies through math. Appearing in the European Research Studies Journal, their findings confirm that AHP turns subjective views on safety into measurable, steady, and traceable rankings useful during high-level or field-based judgments.

Among tools used in port management, AHP stands out in judging maritime risks. When researchers merged DEA with AHP to examine berth performance amid uncertainty, results showed that day-to-day and security-related hazards accounted for nearly two-thirds of the total risk score (Deniozos & Stamatopoulos, 2025). Such an outcome matters here because it reveals how short-term factors may outweigh long-range planning elements if the evaluation system is well designed. Because the earlier work confirmed that AHP can deliver consistent, adaptable guidance for those managing waterway safety, its findings align closely with the path taken in this investigation. Though these three research areas clearly fit together, none so far have been combined within one decision-making structure. Four distinct shortcomings appear in current studies. One issue stands out: fusion center practices and decisions about escalating threats remain unconnected. Actionable intelligence is the goal of fusion centers, yet clear rules tying particular COP setups to defined escalation steps seldom exist. Although Bakamla, KKP, and Hubla operate under defined legal roles, clear procedures for shifting authority to TNI AL during crises remain missing. This creates uncertainty about when civilian oversight ends military intervention begins. Instead of relying on measurable indicators, current Siaga-based judgments depend heavily on personal interpretation, which varies between incidents. Because these assessments leave no written trail, reviewing or validating choices later becomes nearly impossible. Without linking data analysis, alert mechanisms, and structured judgment within one unified system, coordination falters at critical moments.

Gaps like these bring real-world problems into sharp relief. Without clear rules for stepping up responses, Indonesia’s maritime agencies often stumble in familiar ways. Start with cases slipping through the cracks, threats serious enough to demand action stay stuck at minimal alert levels, slowed by red tape, murky responsibilities, or hesitation. Then there are situations blown out of proportion - minor or uncertain events sparking heavy military reactions, fueling tension and risking diplomatic fallout. Throw into the mix disjointed efforts - different organizations acting on conflicting judgments and procedures, their moves clashing instead of aligning, weakening the whole system. Failures like these aren’t hypothetical. Records from maritime accident reviews in

Indonesia confirm they happen. This work responds by introducing and testing the Integrated Maritime Fusion-Governance Model (IMFGM). Rather than remain separate, three elements now connect through it: one, a fusion center design outlining necessary data inputs, outputs, and tools for decision-making in maritime domain awareness; despite prior separation, a tiered alert system now aligns specific threat scenarios with corresponding readiness stages and command responsibilities; further, a built-in analytical engine using AHP translates judgments into measurable rankings across high-level, mid-range, and immediate objectives. Because these parts function together, the model supports reasoned choices about appropriate alert phases when threats arise - using clear comparisons between factors, along with openly derived weighting methods. This study builds on the Analytical Hierarchy Process - a technique introduced by Saaty (1980) tested widely when examining matters tied to security, defense, and systems of rule. What makes AHP fit for challenges in maritime security governance lies in its flexibility: it handles numbers alongside descriptive factors, breaks down complicated choices into layered parts, flags inconsistencies in human judgment, while delivering outcomes clear enough to trace back. Within this work, the AHP model unfolds across three tiers. At the top, labeled Level 0, sits a central aim solid maritime situational awareness that supports timely escalation calls. One level below, Level 1, groups three main considerations: strategic usefulness, operational effectiveness, and value at the tactical edge. Looking ahead shapes how threats are tracked over time, along with spotting patterns and building early signals. Because clarity matters during missions, shared situational pictures improve teamwork across agencies and boost how well data moves between them. Response actions depend heavily on whether interceptions can be managed precisely and whether targets are correctly identified. Breaking down level two reveals paired elements beneath broader goals indicators pair with evolving threat patterns in strategic planning; common operating pictures link to joint efforts in operational work; interception management ties closely to precision targeting in tactical settings. At the third tier sit four possible choices aligned directly with readiness stages labeled Siaga 4 down to Siaga 1. This study aims at three distinct goals. First comes building the IMFGM, a blend of concept and calculation - meant for choices on sea-based alert progressions. Following that, the AHP method enters play, weighing how much strategic, operational, and tactical factors matter when setting Siaga stages. Then unfolds the search for the best threat-response tier, tested across made-up situations where changing inputs reveal whether rankings hold firm. Every aim ties back plainly to missing pieces found earlier in published work.

The contributions of this study are theoretical, methodological, and practical in character. The theoretical contribution extends Bueger's assemblage framework by adding explicit decision and escalation dimensions to maritime security governance analysis. Whereas existing assemblage approaches describe institutional complexity, the IMFGM provides a mechanism for navigating that complexity through structured, quantifiable decision criteria. The methodological contribution consists of the first AHP-based governance model specifically designed for maritime escalation decisions, providing a template replicable across archipelagic states facing similar fragmentation challenges. The practical contribution is a policy-relevant decision support tool for Indonesian stakeholders including Bakamla, TNI AL, KKP, and Hubla, offering transparent escalation criteria and defensible decision protocols. For maritime security stakeholders specifically, the IMFGM delivers differentiated value. Bakamla receives clear role definition for Siaga 3 and 4 conditions monitoring, vigilance, and COP development with defensible handover criteria to military authorities when threat conditions escalate. TNI

Angkatan Laut obtains prioritized justification for intercept control capability as the dominant decision weight (predicted to approach 0.473 globally), with clear escalation trigger points that distinguish military-led from civilian-led response domains. KKP gains structured integration of threat trend and indicator data into national COP architecture, enabling data-driven enforcement prioritization. Hubla secures defined coordination responsibilities within operational criterion, improving vessel traffic management and early warning integration. The Coordinating Ministry for Political, Legal, and Security Affairs receives standardized escalation protocols that reduce bureaucratic paralysis and provide legal defensibility for escalation decisions. The proposed National Fusion Center receives hierarchical data priorities guiding efficient sensor and resource allocation. Maritime industry operators and coastal communities benefit from predictable escalation environments with transparent threat response protocols, reducing operational disruption and improving trust in maritime security institutions.

LITERATURE REVIEW

Maritime Security Governance

The concept of maritime security governance has evolved dramatically in recent decades, shifting from a narrow focus on naval defense to a multidimensional framework encompassing national, economic, human, and environmental dimensions (Otto & Menzel, 2024). Traditional approaches to maritime security have historically privileged state-centric and economic perspectives focusing on sovereign territorial integrity and the protection of global trade routes, while relegating human and ecological considerations to secondary status. However, a growing body of scholarship argues that a more holistic approach is urgently needed, one that integrates state, economic, human, and environmental security to make maritime governance more equitable, sustainable, and responsive to contemporary social and ecological challenges (Fabinyi et al., 2025). This expanded conceptualization recognizes that maritime security cannot be reduced to naval power projection or port protection but must instead account for the welfare of coastal communities, the sustainability of marine resources, and the resilience of ocean ecosystems. The governance complexity inherent in maritime security is particularly pronounced in archipelagic states, where geographic fragmentation multiplies institutional interfaces and jurisdictional ambiguities. Indonesia, as the world's largest archipelagic nation comprising over 17,000 islands with a coastline stretching 108,000 kilometers and a sea area covering approximately 6.9 million square kilometers, exemplifies these governance challenges with unusual intensity (Isjchwansyah, 2025). The country's strategic position astride four of the world's most consequential maritime chokepoints, the Straits of Malacca, Sunda, Lombok, and Makassar which together carry roughly a quarter of global seaborne trade annually, places immense pressure on Indonesian maritime governance institutions to maintain order, enforce sovereignty, and facilitate commerce simultaneously (Ardinal, 2025).

Indonesia's maritime governance architecture involves an exceptionally fragmented institutional landscape. The Indonesian Maritime Security Agency (Bakamla), established in 2014 under Article 59 Paragraph (3) of the Maritime Affairs Law, was intended to serve as a coordinating body for maritime security and safety patrols. However, a recent authoritative analysis characterizes Indonesia's maritime enforcement system as a "multi-agency, multi-task" patchwork where any institution with legal authority to perform coastguard functions functions as part of an informal coastguard ecosystem (Syailendra, 2026). These institutions include TNI Angkatan Laut (the navy), KKP (Ministry of Marine Affairs and Fisheries), KPLP (Directorate of Sea Transportation under the Ministry of Transportation), Polairud (the police maritime arm), customs authorities, and Bakamla itself. On paper, responsibilities appear divided along functional lines: TNI-AL secures the exclusive economic zone (EEZ), KKP enforces fisheries law, KPLP oversees shipping safety, and Bakamla handles maritime security and gray-zone incidents. In practice, however, task overlaps and jurisdictional ambiguities dominate (Syailendra, 2026). The fragmented nature of Indonesian maritime governance has significant operational consequences. Domestic contestation over the formalization of Indonesia's coastguard reveals a central constraint of democratic-era governance: even modest reforms such as establishing a unified coastguard are repeatedly obstructed by bureaucratic actors protected by long-standing legal mandates (Syailendra, 2026). The struggle is not merely institutional but conceptual, as competing worldviews shape how different agencies claim ownership of Indonesia's maritime agenda. Major shifts therefore occur not through strategic directives but through slow, hard-fought battles over legal wording and jurisdiction. The policy reality, as one analyst concludes, is clear: Indonesia will not have a unified coastguard any time soon, and the system will remain fragmented and multi-agency for the foreseeable future (Syailendra, 2026).

Maritime Domain Awareness

Maritime Domain Awareness constitutes a foundational pillar of effective maritime security governance. MDA refers to the effective understanding of anything associated with the maritime domain that could impact security, safety, economy, or environment (Haryono et al., 2025). Contemporary MDA systems integrate data from multiple sources, including Automatic Identification Systems (AIS), coastal radar networks, satellite imagery, airborne surveillance platforms, and human intelligence sources, to construct a comprehensive operational picture of maritime activities. The technological dimensions of MDA have advanced considerably. AIS technology provides automated vessel tracking but suffers from limitations including voluntary compliance, signal spoofing, and complete deactivation by vessels seeking concealment. Recent research has therefore focused on fusing cooperative AIS data with non-cooperative synthetic aperture radar (SAR) satellite imagery to identify dark vessels those operating with disabled or manipulated transponders enabling timely detection of vessels involved in illegal fishing, smuggling, or other illicit activities (Agorku et al., 2025). This fusion approach links visual detections with AIS data to validate cooperative traffic and characterize unknown vessels, significantly enhancing MDA capability beyond what either system can achieve independently.

The Common Operational Picture (COP) represents the analytical product that transforms raw data into actionable intelligence. A COP is a unified, real-time visualization of the maritime environment compiled from multiple sources across surface, subsurface, aerial, and space-based sensors. The COP enables maritime security operators to maintain situational awareness across vast areas, detect anomalies, cue surveillance assets to areas of interest, and coordinate response operations across multiple agencies. In the Indonesian context, TNI AL has implemented strategic measures to optimize MDA including the integration of radar-based monitoring systems, AIS enhancement, satellite imagery utilization, and collaborative arrangements with domestic agencies and regional partners (Haryono et al., 2025). However, persistent challenges remain in system interoperability, infrastructure limitations in remote archipelagic regions, and human resource capacity development.

Fusion Centers and C4ISR

Fusion centers serve as the institutional mechanism for achieving integrated MDA. Drawing from C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) frameworks originally developed in military contexts, maritime fusion centers aggregate data from multiple sources, analyze information across temporal and spatial scales, and disseminate actionable intelligence to authorized stakeholders. The relationship between MDA and C4ISR is symbiotic: MDA provides the raw awareness, while C4ISR provides the command architecture that translates awareness into coordinated action. The operational backbone of maritime defense, effective C4ISR enables unified command, situational awareness, and real-time coordination through multi-source fusion rather than siloed sensors by integrating AIS, SAR, electro-optical imagery, radio frequency data, behavioral analytics, and intelligence reporting into a coherent operational picture (Windward, 2025). A fused, multi-domain picture enables naval forces to deliver maximum operational effect and presents substantial value to coalition and partner operations across all domains.

The practical implementation of fusion center concepts varies across regional contexts. Singapore's Information Fusion Centre (IFC), established by the Republic of Singapore Navy in 2009, serves as a regional hub for maritime security information sharing. The IFC pioneered the deployment of international liaison officers from partnering navies and enforcement agencies physically located at the centre, enabling real-time information exchange and coordinated operational responses. Recent analysis suggests that while MDA efforts have increasingly focused on technological solutions, established practical means of cooperation particularly the system of deploying liaison officers to regional information sharing centers should not be neglected, as these personnel-level relationships provide crucial context and trust that pure data sharing cannot replicate.

Escalation Theory in Security

Escalation theory, initially developed in nuclear deterrence and conventional military contexts, examines how conflicts transition from low-intensity competition to high-intensity confrontation. The core insight of escalation theory is that decision-making under threat conditions is particularly susceptible to cognitive biases, institutional pressures, and information asymmetries. In structured escalation systems, these vulnerabilities are mitigated through predefined thresholds, clear authority assignments, and graduated response options. Threat-based response systems have been implemented across multiple security domains. In cyber security, for example, threat escalation matrices provide structured hierarchical frameworks that define how security threats progress through different response levels based on severity, impact, and urgency, while outlining clear roles and responsibilities at each stage (Orzechowski, 2025). These matrices enable systematic escalation decisions rather than ad hoc judgments, reducing the risk of both under-response and over-response.

In the maritime domain, structured escalation logic remains notably underdeveloped. Existing alert state systems such as the Indonesian Siaga framework provide formal designations for different threat conditions but lack explicit decision criteria linking specific threat indicators to appropriate response levels. Siaga 4 represents normal peacetime monitoring conditions. Siaga 3 indicates increased vigilance with enhanced information collection. Siaga 2 denotes heightened alert requiring active interdiction capabilities and civil–military integration. Siaga 1 represents maximum readiness for armed confrontation with full military resources deployed. However, the absence of quantitative criteria for transitions between these levels means that escalation decisions remain subject to subjective judgment rather than systematic assessment. The "militarization dilemma" identified by Bueger highlights the central tension: naval forces are necessary to combat piracy, trafficking, and gray-zone operations, yet their presence can simultaneously exacerbate geopolitical tensions and provoke escalatory responses from other actors (Bueger et al., 2025). This dilemma underscores the critical importance of structured escalation logic that enables proportionate, graduated, and reversible responses rather than binary peaceful-or-hostile categorizations.

Analytical Hierarchy Process (AHP) in Decision Making

The Analytical Hierarchy Process, originally developed by Saaty (1980), provides a structured multi-criteria decision-making methodology that has found extensive application across security, defense, and governance contexts. AHP decomposes complex decisions into hierarchical components, enables pairwise comparison of criteria and alternatives at each level, calculates priority weights through eigenvalue methods, and provides consistency checking to identify unreliable judgments. Recent applications of AHP in maritime security contexts demonstrate its methodological versatility. A study employing integrated DEA and AHP analysis for berth efficiency under risk conditions found that operational and safety risks combined to contribute a composite weight exceeding 63 percent in the risk assessment hierarchy, demonstrating that tactical and operational criteria can legitimately dominate strategic considerations when risk assessment frameworks are properly structured (Deniozos & Stamatopoulos, 2025). Another study applied fuzzy AHP with TOPSIS to select optimal maritime security policy for Indonesia, finding that a multi-task single agency model was most strongly recommended, influenced by factors including technology, regulations, infrastructure, economics, politics, and socio-culture (Hozairi et al., 2019).

AHP has also been applied to specific Indonesian maritime defense challenges. Research examining the optimization of TNI AL operational elements for countering gray-zone threats in the North Natuna Sea found that gray-zone response capability (26.0 percent) and surveillance and intelligence capability (22.8 percent) were the highest-priority criteria, with presence operations and persistent surveillance emerging as the most important subcriteria (Wardana et al., 2025). This finding is methodologically instructive, as it demonstrates that information superiority and sustained presence outweigh pure combat power in determining operational effectiveness against gray-zone threats. Additional Indonesian AHP applications include the development of submarine force structure, where vision and mission, shipyard capacity, government policy, technology transfer, and budget were identified as the five highest-priority alternative variables (Prayitno & Yanuar, 2020). Similarly, a SWOT-AHP analysis of maritime safety governance identified international and national regulations (31.1 percent), maritime education and training (14.8 percent), and Port State Control supervisory capacity (13.6 percent) as the most critical factors for strengthening maritime safety regulation and oversight (Riyadi & Erliyani, 2025).

Research Gap Synthesis

The preceding literature review reveals four distinct research gaps that the present study addresses:

1. Gap 1: No integrated model combining fusion center operations, escalation systems, and quantitative decision modeling. The literature on fusion centers focuses on data integration and information sharing but rarely incorporates explicit escalation decision logic. Conversely, escalation theory as applied to maritime security lacks systematic integration with fusion center information products. No existing framework connects the COP produced by fusion centers to specific alert state decisions through quantifiable decision criteria.
2. Gap 2: No quantitative escalation logic for Siaga 1–4 levels. While the Siaga framework provides formal alert state designations, it lacks operationalized

decision criteria linking threat indicators to specific escalation levels. This absence means that transitions between Siaga levels cannot be systematically justified, audited, or improved through empirical analysis.
3. Gap 3: No AHP application specifically addressing integrated maritime governance escalation. Existing AHP applications in Indonesian maritime contexts have focused on specific operational problems including gray-zone response optimization and submarine force development. However, no AHP study has addressed the higher-order governance question of how strategic, operational, and tactical criteria should be weighted to determine appropriate escalation levels across the Siaga framework.
4. Gap 4: No structured civil–military coordination protocol for maritime escalation. The fragmented Indonesian maritime governance system lacks clear protocols for transitioning between civilian-led monitoring (Bakamla, KKP, Hubla) and military-led interdiction (TNI AL). This absence creates dangerous ambiguity in threat response and undermines both institutional accountability and operational effectiveness.

METHODS

This study adopts a model-based quantitative approach situated within the broader tradition of multi-criteria decision analysis (MCDA). The research design is fundamentally decision-analytic, seeking to operationalise the evaluation of maritime escalation alternatives through structured, replicable, and transparent computational procedures. Given the exploratory nature of the investigation and in the absence of directly accessible empirical expert data. The present study employs a simulated, theoretically grounded analytical framework to demonstrate the internal logic and operational feasibility of the proposed Integrated Maritime Fusion-Governance Model (IMFGM). The methodological choice of the Analytical Hierarchy Process (AHP) is motivated by several distinctive advantages that render it particularly well-suited to maritime security governance contexts. First, AHP accommodates both quantitative and qualitative criteria within a unified analytical framework, enabling the structured decomposition of complex decision problems into hierarchical components (Top & Bal Beşikçi, 2025). Second, AHP provides systematic procedures for deriving priority weights from pairwise comparison matrices, thereby transforming subjective expert judgments into auditable, quantifiable assessments. Third, AHP incorporates consistency checking mechanisms that identify unreliable judgments, thereby enhancing the credibility and defensibility of decision outputs (Podlesnik et al., 2025). Fourth, AHP facilitates sensitivity analysis that tests the robustness of rankings under varying criteria weight scenarios, a feature particularly valuable in policy contexts where stakeholder priorities may legitimately differ.

The hierarchical structure of the IMFGM consists of three principal levels, following the canonical AHP decomposition originally formalised by Saaty (1980) and subsequently refined in numerous security and governance applications (Đelović et al., 2025).

1. Level 0: Goal, the overarching goal of the decision hierarchy is the achievement of strong maritime situational awareness sufficient to enable timely, proportionate, and defensible escalation decisions across Indonesia's fragmented maritime governance architecture. This goal reflects the fundamental policy objective underlying the IMFGM: to replace ad hoc, institutionally driven escalation judgments with systematic, criteria-based decision protocols.
2. Level 1: Primary Criteria Three primary criteria constitute the first level of the hierarchy: Strategic Utility (C1) concerns the long-term, awareness-oriented dimensions of maritime governance, including indicator development, threat trend analysis, and strategic intelligence production. Strategic utility corresponds to the anticipatory and planning functions of maritime security governance.

Operational Utility (C2) addresses the intermediate, coordination-oriented dimensions of maritime governance, including the construction and maintenance of the Common Operational Picture (COP), inter-agency information sharing, and coordination among civilian maritime authorities (Bakamla, KKP, Hubla) as well as between civilian and military actors. Tactical Utility (C3) encompasses the immediate, response-oriented dimensions of maritime governance, including intercept control capability and target accuracy in interdiction operations. Tactical utility aligns most closely with the military readiness and response functions of TNI Angkatan Laut under elevated Siaga conditions. The tripartite distinction among strategic, operational, and tactical utility follows established military and security doctrine, while also reflecting the functional differentiation of Indonesian maritime institutions as documented in the literature (Bueger et al., 2025).

3. Level 2: Sub-Criteria Each primary criterion is decomposed into two constituent sub-criteria, yielding a total of six evaluation dimensions: Under Strategic Utility (C1): SC1: Indicators refers to the quality, timeliness, and relevance of strategic indicators used to assess maritime threat environments. SC2: Threat Trends concerns the analysis of medium to long-term patterns in maritime security challenges, including illegal fishing, trafficking, and gray-zone operations. Under Operational Utility (C2): SC3: Common Operational Picture (COP) addresses the integration of diverse data sources (AIS, radar, satellite, intelligence) into a unified, real-time visualisation of maritime activities. SC4: Coordination refers to the effectiveness of inter-agency communication, information sharing protocols, and joint operational planning among Bakamla, KKP, Hubla, and TNI AL. Under Tactical Utility (C3): SC5: Intercept Contro concerns the capability to conduct interdiction operations, including vessel boarding, pursuit, and engagement. SC6: Target Accuracy refers to the precision with which maritime threats are identified, tracked, and engaged, including the avoidance of misidentification and collateral consequences. The selection of these six sub-criteria is informed by the maritime security literature as well as by the institutional mandates and operational realities of Indonesian maritime governance (Haryono et al., 2025).
4. Level 3: Decision Alternatives The alternatives at the lowest level of the hierarchy correspond to the four alert states of the Indonesian Siaga escalation framework: Siaga 4 – normal peacetime monitoring conditions characterised by routine patrols, passive surveillance, and civilian-led coordination. Siaga 3 increased vigilance in response to elevated threat assessments, with enhanced information collection and inter-agency information sharing. Siaga 2 heightened alert requiring active interdiction capabilities, civil-military integration, and prepared deployment of armed response assets. Siaga 1 maximum readiness for armed confrontation, with full military resources deployed and lethal force authorised. The Siaga framework is formally recognised within Indonesian maritime security doctrine, though it currently lacks explicit quantitative decision criteria for transitions between levels, a gap the present methodology directly addresses.

A central methodological challenge confronting this study is the absence of directly accessible empirical expert judgments from Bakamla, TNI AL, KKP, and Hubla personnel. In response to this constraint, the study employs a simulated expert judgment approach constructively, following established practices in MCDA research where proof-of-concept demonstrations precede empirical validation. All pairwise comparison matrices are constructed using the standard by Saaty (1980), nine-point absolute judgment scale, where a value of 1 indicates equal importance, 3 indicates moderate importance, 5 indicates strong importance, 7 indicates very strong importance, and 9 indicates extreme importance. Reciprocal values are used for the inverse comparisons. The simulated judgments are generated systematically rather than arbitrarily: each comparison is explicitly justified in terms of theoretical maritime escalation logic and operational doctrine.

The simulated pairwise comparisons are designed to embody a tactical-dominant escalation logic that is consistent with:

- The escalation theory literature, which generally emphasises the increasing weight of response capability as threat severity escalates;
- The operational realities of maritime security, where intercept control becomes progressively more critical as situational awareness transitions from monitoring to response;
- The institutional mandates of Indonesian maritime actors, wherein TNI AL assumes lead authority at higher Siaga levels;
- The empirical findings of studies such as Đelović et al. (2025), which demonstrate that operational and safety risks can collectively dominate strategic considerations in maritime risk hierarchies, contributing composite weights in excess of 63% in certain contexts.

To ensure the internal validity of the simulated AHP model, the following safeguards are implemented:

- All pairwise comparison matrices are required to satisfy the consistency ratio (CR) threshold of 0.1, as established by Saaty (1980) and reaffirmed in recent methodological studies (Top & Bal Beşikçi, 2025);
- Where multiple theoretically plausible comparisons exist, conservative estimates favouring lower differentiation are selected to avoid artificial inflation of weights;
- The overall hierarchical structure follows the canonical AHP decomposition, enabling cross-study comparability;
- Sensitivity analysis explicitly tests the robustness of results to variations in criteria weights.

The results derived from simulated data should not be interpreted as empirical evidence of actual institutional preferences among Indonesian maritime security stakeholders. Rather, the findings constitute an analytical demonstration of the IMFGM's capability and internal decision logic. Empirical validation using actual expert panels remains a necessary direction for future research.

RESULTS AND DISCUSSIONS

Following the hierarchical AHP computation described in the preceding methodology section, this section reports the quantitative findings of the study. The results are structured across four analytical levels: (1) criteria weights at the highest decision level, (2) sub-criteria weights and their global prioritisation, (3) the final ranking of Siaga alternatives, and (4) sensitivity analysis examining the stability of the ranking under alternative weight configurations. All calculations were executed with consistency ratios maintained below the 0.10 threshold, ensuring the mathematical validity of the simulated comparisons. At the highest level of the AHP hierarchy, the three primary criteria Strategic Utility (C1), Operational Utility (C2), and Tactical Utility (C3) were evaluated with respect to the overarching goal of strong maritime situational awareness. The pairwise comparison matrix and the resulting priority weights are presented in Table 1.

Table 1. Pairwise comparison matrix and priority weights for Level 1 criteria

	C1	C2	C3	Weight
C1	1	1/3	1/5	0.11
C2	3	1	1/3	0.26
C3	5	3	1	0.63

Note: λmax = 3.04; CI = 0.02; CR = 0.034 < 0.10, indicating acceptable consistency.

The results reveal a clear and substantial dominance of Tactical Utility (0.63) over Operational Utility (0.26) and Strategic Utility (0.11). This finding indicates that within the simulated decision environment grounded in theoretical escalation logic response-oriented capabilities are weighted nearly six times more heavily than strategic foresight. The prioritisation aligns with the operational imperatives of maritime security, where the capacity to interdict and neutralise immediate threats consistently outweighs longer-term analytical functions, particularly as threat severity escalates (Đelović et al., 2025). This pattern is consistent with findings from other maritime AHP applications, where operational and safety risks were shown to dominate strategic considerations, contributing composite weights exceeding 63 per cent in risk assessment hierarchies.

The decomposition of each primary criterion into two constituent sub-criteria enables a more granular understanding of the drivers of effective maritime security governance. Table 2 presents the local weights of sub-criteria with respect to their parent criteria.

Table 2. Local weights of sub-criteria under each parent criterion

Parent Criterion	Sub-Criterion	Local Weight
Strategic (C1)	SC1: Indicators	0.33
Strategic (C1)	SC2: Threat Trends	0.67
Operational (C2)	SC3: Common Operational Picture	0.67
Operational (C2)	SC4: Coordination	0.33
Tactical (C3)	SC5: Intercept Control	0.75
Tactical (C3)	SC6: Target Accuracy	0.25

Source: Processed by Authors, 2026

Under the Strategic criterion, SC2: Threat Trends (0.67) is weighted twice as heavily as SC1: Indicators (0.33). This reflects the assumption that the dynamic analysis of emerging threat patterns contributes more to strategic utility than the static compilation of indicator lists. Under the Operational criterion, SC3: Common Operational Picture (0.67) assumes dominance over SC4: Coordination (0.33), consistent with the premise that shared situational awareness is a prerequisite for effective inter-agency coordination. Under the Tactical criterion, SC5: Intercept Control (0.75) substantially outweighs SC6: Target Accuracy (0.25), reflecting the operational logic that the capability to interdict even with imperfect precision is more critical than perfect targeting absent interdiction capacity. The integration of local weights with their parent criterion priorities produces the global weights presented in Table 3. The global weight represents each sub-criterion's overall contribution to the decision goal, accounting for both its local importance and the importance of its parent criterion.

Table 3. Global weights of all sub-criteria

Sub-Criterion	Local Weight	Parent Weight	Global Weight	Rank
SC1: Indicators	0.33	0.11	0.036	6
SC2: Threat Trends	0.67	0.11	0.074	5
SC3: COP	0.67	0.26	0.174	2
SC4: Coordination	0.33	0.26	0.086	4

SC5: Intercept Control	0.75	0.63	0.473	1
SC6: Target Accuracy	0.25	0.63	0.158	3

Source: Processed by Authors, 2026

The global weights reveal a pronounced concentration of decision priority. SC5: Intercept Control commands a global weight of 0.473, accounting for nearly half of the entire decision hierarchy's prioritisation. This finding is consistent with the military-centric logic that underlies higher Siaga levels, where the capacity to board, pursue, and engage vessels forms the core operational requirement. The Common Operational Picture (SC3) ranks second with a global weight of 0.174, confirming the importance of shared situational awareness, though at less than half the weight of intercept control. Target Accuracy (SC6) follows at 0.158, while Coordination (SC4) and the strategic sub-criteria (SC2, SC1) rank substantially lower. This distribution suggests that, under the simulated tactical-dominant logic, the decision to escalate privileges response capability over awareness and over coordination, a finding with significant implications for maritime governance design. The overall scores for the four Siaga alternatives, calculated through hierarchical synthesis across all sub-criteria, are presented in Table 4. The ranking order indicates the simulated optimal escalation level under the baseline decision criteria.

Table 4. Final aggregated scores and ranking of Siaga alternatives

Alternative	Final Score	Rank
Siaga 1	0.46	1
Siaga 2	0.31	2
Siaga 3	0.15	3
Siaga 4	0.08	4

Source: Processed by Authors, 2026

Siaga 1 emerges as the highest-ranked alternative with a score of 0.46, followed by Siaga 2 (0.31), Siaga 3 (0.15), and Siaga 4 (0.08). The ordering is monotonic: higher alert states correspond to higher decision scores, reflecting the underlying logic that increased threat severity demands elevated response postures. The magnitude of differentiation between Siaga 1 and Siaga 2 a difference of 0.15 points exceeds the differentiation between Siaga 2 and Siaga 3 (0.16 points) and substantially exceeds the difference between Siaga 3 and Siaga 4 (0.07 points). This suggests that the simulated decision environment favours Siaga 1 not merely as a marginal improvement over Siaga 2 but as a qualitatively distinct preferred state. However, as the sensitivity analysis below demonstrates, this preference is not absolute but contingent on the weight assigned to tactical utility.

Table 5. Sensitivity analysis results under alternative criteria weight configurations

Scenario	C1	C2	C3	Dominant Alternative	Key Observation
Baseline	0.11	0.26	0.63	Siaga 1	Baseline tactical dominance
Reduced Tactical	0.20	0.40	0.40	Siaga 2	Tactical ↓ → Siaga 2 ascends
Elevated Strategic	0.30	0.20	0.50	Siaga 3 rises	Strategic ↑ → awareness elevated
Balanced	0.33	0.33	0.33	Siaga 2 (most stable)	Neutral weighting

Source: Processed by Authors, 2026

In the Reduced Tactical scenario, where the weight of Tactical Utility is decreased to 0.40 with redistributed weight allocated proportionally to Strategic and Operational Utility, Siaga 2 becomes the dominant alternative. This finding demonstrates that while the baseline model privileges the highest alert state, the system is not rigid: when tactical considerations are de-emphasised, hybrid governance approaches become optimal. In the Elevated Strategic scenario, increasing Strategic Utility to 0.30 produces a partial convergence in scores among the top three alternatives, with Siaga 3 showing a notable rise in relative preference. This suggests that governance philosophies emphasising long-term threat assessment and strategic intelligence production would favour monitoring-intensive postures over immediate military engagement. The Balanced scenario, where all three criteria are assigned equal weight (0.33 each), yields Siaga 2 as the most stable alternative, indicating that under conditions of weight uncertainty, the mid-level alert state represents a conservative default. Collectively, the sensitivity analysis confirms that the IMFGM is adaptive rather than rigid. The model produces interpretable, monotonic shifts in ranking that correspond systematically to changes in input priorities, demonstrating its utility as a decision-support tool capable of accommodating divergent stakeholder perspectives. The analytical results derived from the AHP simulation provide clear evidence that under the tactical-dominant logic embedded in the simulated pairwise comparisons, response capability is weighted substantially more heavily than situational awareness. Intercept Control emerged as the single most influential decision factor, commanding a global weight of 0.473 and accounting for nearly half of the hierarchical prioritisation. This pattern accords with escalation theoretic expectations: as threat severity increases, the capacity to interdict rapidly becomes the binding constraint on system effectiveness. The finding is also consistent with broader AHP applications in maritime contexts, where operational and safety risks together contributed composite weights exceeding 63 per cent in risk assessment hierarchies (Đelović et al., 2025).

The dominance of intercept capability, however, should not be interpreted as an argument for the permanent prioritisation of military responses over civilian-led monitoring. The sensitivity analysis reveals that Siaga 1 is optimal only when tactical utility exceeds approximately 0.60 in weight. When tactical considerations are reduced to 0.40, Siaga 2 becomes optimal. This indicates that the appropriate escalation level is not a fixed property of the system but a function of the relative priority assigned to strategic, operational, and tactical goals. The model therefore provides a structured mechanism for making this prioritisation explicit rather than presuming any single doctrinal position. A second important finding concerns the relationship between COP and coordination within the operational criterion. The local weight for COP (0.67) substantially exceeds that for coordination (0.33), suggesting that shared situational awareness is treated as a prerequisite for, rather than a substitute for, effective inter-agency coordination. This finding reinforces the C4ISR literature, which emphasises that a fused, multi-domain picture is essential for enabling unified command, situational awareness, and real-time coordination. The implication for policy is clear: investments in COP development should precede or accompany efforts to strengthen coordination mechanisms, not follow them.

The fragmented character of Indonesian maritime governance, long identified as a constraint on policy effectiveness, has recently been complicated by legal developments that intensify civil-military integration. The revised TNI Law of 2025 expands the number of civilian institutions where active military personnel may serve from ten to fourteen, explicitly including Bakamla. Under this provision, active Navy personnel may now serve in the coast guard while remaining members of the Navy (Darmawan & Prasetya, 2025).

Critics argue that this development formalises and intensifies the creeping militarisation of what was intended as a civilian institution, undermining Bakamla's career merit system and privileging naval officers over civilian-recruited coast guard officers (Darmawan & Prasetya, 2025). The present AHP results provide quantitative evidence relevant to this governance debate. The strong priority accorded to Intercept Control (global weight 0.473) aligns with the operational realities that proponents of naval secondment to Bakamla invoke: namely, that limited civilian resources necessitate military support. However, the AHP results also reveal that this tactical dominance is conditional, not absolute. In sensitivity scenarios where tactical weight is reduced, Siaga 2 a hybrid civil-military alert state becomes optimal. The implication is that while intercept capability is critical, it does not inherently require active military command of coast guard operations. Hybrid governance models where civilian agencies lead monitoring and coordination (Siaga 3 and Siaga 4) while military assets provide trained augmentation under civilian strategic direction remain viable and, under some weight configurations, optimal. The Indonesian Navy's current modernisation trajectory, which includes emphasis on joint C4ISR development and interoperable communications, reflects recognition of these governance requirements (Gangadharan, 2025). The AHP results suggest that interoperability investments should prioritise the integration of intercept control data into the national COP, as this pairing SC5 and SC3 together account for nearly two-thirds of total decision weight.

The main theoretical contribution of this study is the extension of Bueger's assemblage framework for maritime security governance through the addition of explicit decision and escalation dimensions. Bueger & Edmunds (2024), reconceptualised maritime security not as a monolithic condition but as a complex assemblage of institutions, mechanisms, and practices. While this assemblage perspective effectively describes institutional complexity, it has historically lacked a mechanism for navigating that complexity through structured, quantifiable decision criteria. The IMFGM supplies that mechanism. By translating the abstract goal of strong maritime situational awareness into a hierarchical decision structure with measurable criteria weights, the IMFGM demonstrates how the descriptive insights of assemblage theory can be operationalised for policy analysis. The AHP framework does not replace qualitative governance analysis but rather complements it, providing a systematic method for making prioritisation trade-offs explicit, auditable, and replicable across decision contexts. The sensitivity analysis component is particularly valuable in this regard, as it acknowledges that governance priorities are legitimately contested across stakeholders and provides a method for mapping the consequences of alternative prioritisation schemes.

A second theoretical contribution concerns escalation logic. The maritime security literature has extensively documented the "militarisation dilemma". The observation that naval forces are necessary to combat non-traditional threats yet their presence can simultaneously exacerbate geopolitical tensions. The IMFGM offers a partial resolution to this dilemma by formalising escalation as a graduated, reversible, multi-criteria decision rather than a binary peaceful-or-hostile categorisation. The four Siaga levels, linked to specific configurations of indicator thresholds and response authorities, enable proportionate responses calibrated to threat severity.The findings carry direct policy implications for Indonesian maritime governance institutions. First, the strong global weight of Intercept Control (0.473) suggests that interoperability investments should be prioritised accordingly. The bilateral naval exercises conducted through CARAT Indonesia, which include focused training on maritime domain awareness and combined operational coordination, provide institutional platforms for developing the patterns of joint response that the IMFGM privileges under higher Siaga conditions (Moore, 2025).

Second, the prominence of COP (global weight 0.174) supports the case for a dedicated national maritime fusion centre. The proposed centre would aggregate data from AIS, radar, satellite, and intelligence sources into a unified COP, enabling the transition from isolated sensor data to validated, actionable intelligence that supports interdiction, deterrence, and crisis management. The Ghana Maritime Authority's recent proposal to establish a national maritime fusion centre, explicitly designed to unite key maritime actors for threat detection and response, offers a comparable institutional model that Indonesia could adapt (Bueger et al., 2025). Third, the elevated ranking of Siaga 2 under balanced and reduced-tactical scenarios indicates that hybrid civil-military coordination mechanisms require strengthening. The current Bakamla-TNI relationship, where active naval officers serve in the coast guard without resigning from the Navy (Darmawan & Prasetya, 2025). It creates operational synergy but also raises accountability concerns. Formalising joint standard operating procedures that clearly delineate civilian-led (Bakamla) from military-led (TNI AL) response domains across Siaga levels would reduce ambiguity without sacrificing intercept capability. Fourth, for the national fusion centre, the hierarchical prioritisation derived from the AHP results provides an empirically grounded basis for resource allocation. Data streams supporting Intercept Control should receive highest priority, followed by COP-relevant information fusion. Coordination-oriented functions, while necessary, should not be allowed to divert attention from the core intercept mission.

The study is not without limitations. The simulated nature of the pairwise comparisons, necessitated by the absence of accessible expert data at this stage, means that the results represent a theoretically plausible configuration rather than an empirical description of actual institutional preferences. Future research should conduct structured AHP surveys with security practitioners from Bakamla, TNI AL, KKP, and Hubla to validate and refine the weight distributions reported here. Additionally, the static AHP framework does not capture real-time decision dynamics; future extensions incorporating Bayesian updating or dynamic AHP methodologies would enable the model to adapt to evolving threat assessments. Notwithstanding these limitations, the IMFGM provides a replicable, transparent, and adaptive architecture for maritime escalation governance that merits further empirical development.

CONCLUSION, RECOMENDATIONS AND LIMITATIONS

This study proposed the Integrated Maritime Fusion-Governance Model (IMFGM) to address the absence of quantitative escalation logic in Indonesian maritime security governance. Using a simulated AHP framework grounded in theoretical escalation theory, the analysis revealed that Tactical Utility (0.63) dominates Strategic and Operational criteria, with Intercept Control holding a global weight of 0.473. Under baseline conditions, Siaga 1 ranked highest (0.46), followed by Siaga 2 (0.31), Siaga 3 (0.15), and Siaga 4 (0.08). Sensitivity analysis confirmed model adaptiveness: reducing tactical weight to 0.40 made Siaga 2 dominant, while elevating strategic weight allowed Siaga 3 to rise. These findings demonstrate that response capability outweighs awareness under escalation conditions, though the optimal Siaga level shifts systematically with governance priorities. The theoretical contribution extends Bueger's assemblage framework by adding decision and escalation dimensions. Methodologically, the IMFGM offers a replicable AHP architecture for archipelagic states. Practically, it provides differentiated value to Bakamla, TNI AL, KKP, and Hubla.

Suggestions, first, create a national marine fusion center with a hierarchy of prioritized data. The global weights of Intercept Control (0.473) and COP (0.174) support this investment. Bakamla should prioritise intercept-relevant data streams for COP integration within the ongoing National Maritime Security System. Second, formalise escalation protocols with quantified decision criteria. Ambiguity over Siaga thresholds risks both under- and over-escalation. The IMFGM's weighted sub-criteria can serve as formal decision rules, e.g., triggering Siaga 2 when SC5 and SC3 jointly exceed a predefined threshold. Third, strengthen civil-military coordination through joint standard operating procedures. The revised TNI Law (2025) expands naval secondment to Bakamla, creating synergy but accountability concerns. Joint SOPs should delineate civilian-led (Siaga 3–4) from military-led (Siaga 1–2) response domains. Fourth, prioritise C4ISR interoperability across navy and civilian fleets. Intercept control and COP together account for nearly two-thirds of decision weight; the Navy's MSALI system and Bakamla's NMSS should converge under common data exchange standards. Fifth, conduct empirical AHP surveys for model calibration. Structured elicitations from 80 mid-career officers across Bakamla, TNI AL, KKP, and Hubla would produce an empirical baseline and reveal agency-specific differences.

Limitations, the most significant limitation is the use of simulated expert judgments. Pairwise matrices were constructed from theoretical escalation logic, not actual practitioner elicitation. Empirical AHP surveys may produce different weight distributions and remain the priority for validation. Second, the static AHP framework cannot capture real-time decision dynamics. Dynamic or Bayesian AHP methods are needed to model how criteria weights evolve as incidents progress. Third, the model assumes rational, unitary decision-making and omits institutional friction bureaucratic politics, overlapping mandates, and divergent strategic cultures among Indonesian maritime agencies. Multi-actor AHP or game-theoretic extensions would better capture inter-agency contestation. Fourth, the hierarchical scope is restricted to three primary criteria and six sub-criteria for tractability; omitted variables such as legal frameworks, financial constraints, and political leadership also influence escalation outcomes. Fifth, the cross-sectional design lacks temporal validation. Longitudinal data would be required to test whether the simulated ranking predicts actual escalation behaviour. Notwithstanding these limitations, the IMFGM provides a transparent, adaptable foundation for future empirical and methodological development.

REFERENCE

Agorku, G., Hernandez, S., Hames, H., & Wagner, C. (2025). *Enhancing Maritime Domain Awareness on Inland Waterways: A YOLO-Based Fusion of Satellite and AIS for Vessel Characterization*. https://doi.org/10.48550/ARXIV.2510.11449

Ardinal, A. (2025, November 11). Southeast Asia's Maritime Gatekeepers: Why Indonesia, Malaysia, and Singapore Now Shape the Future of Global Trade. *Indo Maritim*. https://www.indomaritim.com/2025/11/11/southeast-asias-maritime-gatekeepers/

Bueger, C., & Edmunds, T. (2024). *Understanding Maritime Security*. Oxford University Press. https://doi.org/10.1093/oso/9780197767146.001.0001

Bueger, C., Edmunds, T., & Stockbruegger, J. (2025). UNCLOS under Fire: Recalibrating Maritime Security Governance. *International and Comparative Law Quarterly*, *74*(S1), 85–102. https://doi.org/10.1017/S0020589325101218

Darmawan, A., & Prasetya, J. H. (2025, March 4). The new TNI Law: Will it undermine maritime security governance? *Indonesia at Melbourne*.

https://indonesiaatmelbourne.unimelb.edu.au/the-new-tni-law-will-it-undermine-maritime-security-governance/

Đelović, D., Aleksić, M., Iker, O., & Chalaris, M. (2025). Berth Efficiency Under Risk Conditions in Seaports Through Integrated DEA and AHP Analysis. *Journal of Marine Science and Engineering*, *13*(7), 1324. https://doi.org/10.3390/jmse13071324

Deniozos, N., & Stamatopoulos, T. (2025). Optimizing Maritime Security Strategies: A Methodological Approach Using AHP and SWOT. *EUROPEAN RESEARCH STUDIES JOURNAL*, *XXVIII*(Issue 3), 552–568. https://doi.org/10.35808/ersj/4060

Dolonseda, N. (2022). The Strategic Role of the Defense Industry in Answering the Needs of KRI Capability C4ISR to Achieve Maritime Security in Indonesian National Jurisdictions. *Jurnal Ekonomi, Bisnis & Entrepreneurship*, *16*, 99–106. https://doi.org/10.55208/fmspnp91

Fabinyi, M., Cvitanovic, C., Barclay, K., Bennett, N. J., Chan, E., Nguyen, H., Partelow, S., Song, A. Y., Stacey, N., Steenbergen, D., Suarez, B., & Tanyag, M. (2025). Rethinking maritime security from the bottom up: Four principles to broaden perspectives and centre humans and ecosystems. *Npj Ocean Sustainability*, *4*(1), 29. https://doi.org/10.1038/s44183-025-00130-9

Gangadharan, S. (2025, November 27). Indonesia's Military Modernisation To Counter Grey-Zone Tactics At Sea. *StratNews Global*. https://stratnewsglobal.com/defence-and-security/indonesias-military-modernisation-to-counter-grey-zone-tactics-at-sea/

Haryono, V., Faisol, A., & Achsyan, T. D. (2025). Optimalisasi Maritime Domain Awareness oleh Tentara Nasional Indoensia Angkatan Laut dalam Deteksi Dini Ancaman Maritim. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *8*(11), 12821–12828. https://doi.org/10.54371/jiip.v8i11.9916

Hozairi, H., Buhari, B., Lumaksono, H., & Tukan, M. (2019). Selection of Marine Security Policy using Fuzzy-AHP TOPSIS Hybrid Approach. *Knowledge Engineering and Data Science*, *2*(1), 19–30. https://doi.org/10.17977/um018v2i12019p19-30

Isjchwansyah, Y. R. (2025, March 27). *Budget cuts threaten to sink the Indonesian Maritime Security Agency's operations | East Asia Forum*. https://eastasiaforum.org/2025/03/27/budget-cuts-threaten-to-sink-the-indonesian-maritime-security-agencys-operations/

Moore, R. (2025, June 30). U.S., Indonesian Navies Commence Exercise Cooperation Afloat Readiness and Training Indone. *United States Navy*. https://www.navy.mil/Press-Office/News-Stories/display-news/Article/4229633/us-indonesian-navies-commence-exercise-cooperation-afloat-readiness-and-trainin/

Octavian, A. (2025). PROJECTING FUTURE CHALLENGES IN MARITIME SECURITY. *Proceeding Jakarta Geopolitical Forum*, *8*(1), 86–92. https://doi.org/10.55960/jgf.v8i1.262

Orzechowski, P. (2025, October 21). The Shift in SOC Escalation: From Manual to AI-Powered. *Torq*. https://torq.io/blog/escalation-matrix/

Otto, L., & Menzel, A. (2024). *Global challenges in maritime security: Sustainability and the sea*. Springer Nature.

Podlesnik, L., Bernik, I., & Mihelič, A. (2025). Integrating CTI and threat modeling for cyber resilience: An AHP assessment. *PLOS ONE*, *20*(11), e0335154. https://doi.org/10.1371/journal.pone.0335154

Prayitno, M. E., & Yanuar, Y. (2020). Development Of Indonesia Submarine Force Structure Based On Analytical Hierarchy Process (AHP) And Interpretive Structural

Modeling (ISM) To Control National Interest At Sea. *International Journal of Marine Engineering Innovation and Research*, *5*(3). https://doi.org/10.12962/j25481479.v5i3.7186

Riyadi, S., & Erliyani, D. (2025). Strengthening Indonesia's Maritime Safety Governance: Insights From Ship Accident Trends and Regulatory Oversight. *Jurnal Kebijakan Sosial Ekonomi Kelautan Dan Perikanan*, *15*(2), 123–125.

Saaty, T. L. (1980). *The analytic hierarchy process*.

Sondakh, J. D. N., Ekowanti, M. L., Wahyuni, S., & Sulistiyanto. (2025). Strengthening Maritime Security Governance in Indonesia: A Policy Transformation of Bakamla Toward a Sea and Coast Guard Model. *Social Science and Humanities Journal*, *9*(11), 9469–9475. https://doi.org/10.18535/sshj.v9i11.2112

Syailendra, E. A. (2026). Establishing Mari.me Authority. *IDSS Paper*. https://rsis.edu.sg/rsis-publication/idss/ip26027-establishing-maritime-authority-law-politics-and-indonesias-coastguard/

Top, Ç., & Bal Beşikçi, E. (2025). Optimising ship-marine pilot assignments using AHP and VIKOR: a case study in maritime safety. *Australian Journal of Maritime & Ocean Affairs*, 1–22.

Wardana, V. E. S., Salim, S., & Achnaf, M. (2025). *Optimalisasi Pemilihan Unsur Operasi TNI Angkatan Laut dalam Menghadapi Ancaman Zona Abu-abu di Laut Natuna Utara Menggunakan Metode AHP-TOPSIS | JIIP - Jurnal Ilmiah Ilmu Pendidikan: 14101-14107*. *8*(12), 7.

Windward. (2025, November 12). What Is C4ISR? *Windward*. https://windward.ai/glossary/what-is-c4isr/