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Strengthening Maritime Domain Awareness Through Human Capital and Organizational Capability in Indonesia

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Abstract

Purpose: Indonesia's position as the world's largest archipelagic state makes Maritime Domain Awareness (MDA) a critical element of national resilience. This study aims to evaluate Indonesia's MDA readiness through a multi-layered analytical framework that integrates strategic, operational, and technological dimensions, with particular emphasis on human capital and organizational capability.

Methodology: A mixed-method approach was employed, combining policy analysis, literature synthesis, and quantitative SWOT-based Internal–External Factor Analysis (IFAS–EFAS).

Results: Indonesia's MDA system demonstrates a moderately strong internal capability (IFAS = 2.95) and a favorable external environment (EFAS = 3.10), positioning the country in a progressive growth quadrant. However, significant gaps remain in interagency coordination, technological distribution, and human capital competencies, particularly in data analytics and in cross-sectoral integration.

Conclusions: This study concludes that strengthening MDA requires an integrated strategy that combines institutional consolidation, technological modernization, and human capital development. In particular, this integration should be operationalized through the establishment of a unified interagency command structure, expansion of real-time maritime data fusion systems supported by AI-based analytics, and implementation of a standardized national competency framework to enhance cross-agency coordination and analytical capability.

Limitations: This study is limited by its reliance on simulated IFAS–EFAS scoring and secondary data sources, which may not fully capture real-time institutional dynamics. Future research should incorporate primary data and longitudinal analyses to validate the model

Contributions: The findings contribute theoretically by extending MDA analysis through a multi-layered resilience framework and practically by providing a policy-oriented roadmap for Indonesia's maritime governance.

Keywords: *IFAS–EFAS Analysis, Maritime Domain Awareness (MDA), Maritime Resilience, Strategic Policy Governance*

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1. Introduction

Indonesia's maritime identity defines its geopolitical nature. Spanning more than 17,000 islands and controlling 6.4 million square kilometers of ocean space, including archipelagic sea lanes (ALKI I–III) and an Exclusive Economic Zone (EEZ), Indonesia's maritime domain is both an opportunity and a strategic vulnerability. The nation sits astride vital international sea routes connecting the Indian and Pacific Oceans, rendering it central to global maritime commerce and security (Aly, Pangemanan, Ningrat, Adisasmita, & Hustim, 2025). However, the same geography exposes Indonesia to diverse non-traditional maritime threats, including Illegal, Unreported, and Unregulated (IUU) fishing, piracy, marine pollution, and grey-zone hybrid activities by foreign vessels (Ali & Ayelign, 2022).

Recognizing these challenges, Indonesia launched the "Global Maritime Fulcrum" vision in 2014, emphasizing maritime sovereignty, security, and prosperity in the Indo-Pacific region. At the operational core of this agenda lies Maritime Domain Awareness (MDA), defined as the effective understanding of all maritime-related activities and conditions that could impact national security, safety, and the environment (Hanif Dewan, Ahmed Mustafi, Matos, & Godina, 2024). MDA is essential not only for deterring illegal activities but also for enabling sustainable resource management, maritime safety and environmental protection (Sibali & Jainuddin, 2024).

However, Indonesia's ability to establish comprehensive domain awareness is constrained by three interrelated factors.

1. Strategic fragmentation, where overlapping mandates among institutions (Indonesia Coast Guard, Indonesia Navy, Ministry of Marine Affairs and Fisheries, and the Water and Air Police Corps) hinder unified command and data sharing;
2. Operational inconsistency, reflected in varying capacity levels across regional maritime zones; and
3. Technological asymmetry, as advanced surveillance infrastructure, remains concentrated in western Indonesia, while eastern regions remain under-monitored.

These challenges collectively weaken Indonesia's maritime resilience and its capacity to anticipate, absorb, and adapt to maritime risks. As maritime challenges become increasingly transboundary and data-driven, Indonesia must evolve from traditional reactive patrol models to an integrated, predictive, and technology-enabled MDA ecosystem.

1.1 Problem Statement

Despite multiple government initiatives, Indonesia's MDA implementation remains uneven and lacks comprehensive integration into the health system. Several critical questions arise.

RQ1: What is the current level of readiness of Indonesia's national MDA system across the strategic, operational, and technical layers?

RQ2: Which internal and external factors most significantly affect MDA's performance and sustainability?

RQ3: How can a structured analytical model help prioritize strategies for enhancing Indonesia's maritime resilience through improved MDA?

From a Human Resource Management perspective, the effectiveness of Maritime Domain Awareness (MDA) is not solely determined by technological infrastructure or institutional arrangements but also by the quality of human capital, including competencies in data analytics, interagency coordination, and strategic decision-making. The lack of integrated human resource development frameworks across maritime institutions significantly contributes to fragmented operations and suboptimal performance.

1.2 Research Objectives

This study aims to:

1. Indonesia's overall MDA readiness was assessed using a multi-layered analytical lens.
2. Identify and quantify internal (IFAS) and external (EFAS) factors influencing MDA effectiveness.
3. Develop a conceptual and quantitative model linking MDA strengthening efforts to maritime resilience outcomes.
4. A practical roadmap for integrated maritime governance and surveillance by 2030 is proposed.

1.3 Research Significance

This study contributes to the global and national discourse on maritime governance in three ways.

1. Theoretically, this study advances MDA literature by integrating policy, operational, and technical dimensions into a unified analytical framework applicable to archipelagic states.
2. Empirically, it offers a quantitative simulation (IFAS–EFAS) to estimate Indonesia's MDA performance and preparedness.
3. Practically, it provides policymakers with a roadmap for enhancing interagency collaboration, optimizing technological investments, and strengthening institutional resilience.

Given the increasing complexity of maritime threats, ranging from geopolitical competition to environmental degradation, an adaptive and multi-layered MDA approach is indispensable for Indonesia's aspiration to become a resilient maritime power.

2. Literature Review

2.1 Maritime Domain Awareness (MDA): Theoretical Foundations

Maritime Domain Awareness (MDA) has emerged as a strategic necessity in the 21st-century's complex maritime security environment. According to the U.S. Coast Guard (2005), Maritime Domain Awareness (MDA) is defined as "the effective understanding of anything associated with the global maritime domain that could impact security, safety, economy, or the environment." This concept emphasizes the importance of integrating maritime surveillance, information sharing, and intelligence analysis to support informed decision-making and enhance maritime security (Guard, 2005). This broad definition underscores MDA's multi-dimensional nature MDA of, which integrates data collection, situational awareness, intelligence fusion, and decision-making processes (Dayan, 2024).

Scholars generally conceptualize Maritime Domain Awareness (MDA) as a multi-tiered framework comprising three interrelated dimensions. The Strategic Layer addresses the overarching aspects of national policy, governance structures, and mechanisms for international cooperation, emphasizing the role of legal harmonization and institutional alignment in shaping maritime security priorities (Ayhan, 2023). The Operational Layer focuses on coordination among maritime law enforcement agencies, navies, and coast guards, highlighting the importance of joint operations, standardized procedures, and inter-agency communication in ensuring effective domain management. Finally, the Technical Layer encompasses the deployment of surveillance technologies, sensor networks, and integrated information systems that enable real-time data collection, analysis, and decision-making across maritime zones (Belmoukari, Audy, & Forget, 2023). Together, these three layers provide a comprehensive framework that links governance, operational execution, and technological capability to achieve holistic maritime awareness and resilience.

Studies on complex management systems indicate that effective performance depends on the integration of multiple organizational, technological, and environmental dimensions through coordinated information-sharing mechanisms and standardized processes (Sarker et al., 2025). In the context of Maritime Domain Awareness, this integration is reflected through interoperability among governance, operational, and technological layers supported by shared data systems and common operational pictures. Failure to integrate these dimensions can lead to fragmented awareness, delayed responses, and inefficient resource allocation challenges that many developing maritime nations, including Indonesia, continue to face (Nurisnaeny, Mubaroq, Kaprisma, Perdana, & Budiman, 2024). In the context of Strategic Human Resource Management, organizational performance is strongly influenced by the ability to develop and deploy valuable, rare, and inimitable human capital resources. The Resource-Based View (RBV) suggests that human capital, organizational routines, and knowledge integration capabilities are critical drivers of sustainable competitive advantage. Therefore, strengthening MDA requires not only technological investment but also systematic human capital development and organizational learning.

2.2 Maritime Resilience and National Security

The concept of maritime resilience refers to a state's capacity to anticipate, absorb, recover, and adapt to maritime-related disruptions, whether from natural disasters, illegal activities or geopolitical shocks (Cao & Alon, 2020). It combines elements of security, sustainability, and governance into a

comprehensive framework to maintain functional stability in maritime systems. In resilience theory, the emphasis has shifted from risk prevention to adaptive capacity building. Applied to maritime contexts, resilience involves the following:

1. Maintaining the secure and lawful use of ocean spaces (Jia & Azevedo, 2025);
2. Ensuring the continuity of maritime supply chains (Sibali & Jainuddin, 2024);
3. Sustaining environmental integrity and resource productivity requires effective organizational commitment, stakeholder engagement, and long-term performance management mechanisms (Ochwo & Mwesigwa, 2021);
4. Enabling institutional and technological learning over time (Murphy Jr et al., 2021).

Based on research conducted by (Prakasa, Sawu, & Ulinnuha, 2025), for Indonesia, maritime resilience is not only about defending sovereignty but also ensuring the sustainable use of ocean resources, protecting maritime communities, and upholding international commitments such as the UN Sustainable Development Goal (SDG) 14: Life Below Water. In the Indonesian context, strengthening maritime resilience requires a multidimensional approach that integrates defence readiness with socio-economic and environmental stability. As the world's largest archipelagic state, Indonesia faces a wide spectrum of maritime challenges, including illegal, unreported, and unregulated (IUU) fishing, piracy, transnational crimes, and climate-induced hazards such as rising sea levels and coastal erosion. Therefore, building resilience entails enhancing a nation's capability to respond swiftly to maritime disruptions through coordinated governance, robust surveillance networks, and adaptive policy mechanisms. Furthermore, maritime resilience is closely tied to human security, as millions of Indonesians depend on marine ecosystems for livelihoods and food security (Buitrago R, Barbosa Camargo, & Cala Vitery, 2021).

2.3 MDA in the Global Context

Several countries have implemented integrated MDA frameworks tailored to their national contexts.

1. United States: The National MDA Plan emphasizes multi-agency information fusion through the National Maritime Intelligence Integration Office (NMIO), ensuring real-time operational coordination (Park, 2025).
2. European Union: The Common Information Sharing Environment (CISE) connects maritime authorities across member states for cross-sectoral awareness and surveillance (Dağıstan, Atalay, Aydın Ünal, & Aydın, 2025).
3. Australia and Japan: Both countries have developed regional surveillance networks combining defense, fisheries, and environmental data for Indo-Pacific maritime monitoring (Fei, Shi, & Pan, 2025).

In contrast, Indonesia's MDA system is still emerging, characterized by institutional overlaps and limited interoperability. Lessons from these international cases suggest that robust MDA systems require not only advanced technology but also governance reform and a culture of inter-agency trust (Jia & Azevedo, 2025). While advanced maritime nations have institutionalized integrated MDA architectures, Indonesia's pathway toward a cohesive framework remains in the developmental phase. The primary challenge lies in aligning diverse institutional mandates under a unified national vision that bridges defence, law enforcement, and civilian maritime interests (Murphy Jr et al., 2021). Unlike the United States and the European Union, where data-sharing protocols and interagency command structures are legally mandated, Indonesia's coordination mechanisms are often ad hoc and dependent on situational leadership rather than systemic design (Madhavan, Sharafuddin, & Chaichana, 2022).

Furthermore, the technological infrastructure for real-time data fusion, particularly satellite surveillance, Automatic Identification Systems (AIS), and maritime analytics, remains uneven across agencies and regions (Notteboom, Pallis, & Rodrigue, 2022). To move toward best-practice standards, Indonesia must strengthen legal interoperability, establish a centralized maritime information hub, and promote trust-based collaboration among stakeholders (Shoji, 2024). Adopting lessons from these international experiences could accelerate the transition from fragmented maritime monitoring to an integrated, intelligence-driven MDA system that supports national resilience and regional security.

2.4 Indonesia's Maritime Governance and MDA Development

Indonesia's maritime governance architecture has evolved significantly since the early 2000s. The ratification of the United Nations Convention on the Law of the Sea (UNCLOS) 1982 through Law No. 17/1985 solidified Indonesia's status as an archipelagic state, granting it sovereignty over internal waters and archipelagic sea lanes (Kapidani, Bauk, & Davidson, 2020).

Subsequent policy milestones include the following:

1. Presidential Regulation No. 178/2014 established the Indonesian Coast Guard as the lead MDA institution.
2. Presidential Regulation No. 16/2017 on the Sea Transportation Security System; and
3. Law No. 32/2014 on Marine Affairs integrates environmental, security, and economic dimensions of ocean governance.

Despite these initiatives, Indonesia's maritime management remains decentralized, involving multiple ministries: the Indonesian Navy (Defense), Indonesian Coast Guard (Security coordination), Ministry of Marine Affairs (Fisheries), and Water and Air Police Corps (law enforcement). Fragmented jurisdictional boundaries often lead to redundant operations and inefficiencies in surveillance and information sharing (Suharyo, Manfaat, & Armono, 2017). Moreover, technological asymmetries persist. Most surveillance radars, Automatic Identification System (AIS) receivers, and satellite monitoring systems are concentrated in western Indonesia (Java Sea and Malacca Strait), whereas eastern regions, such as Maluku and Papua, remain under-monitored (Supangat et al., 2023). This uneven coverage hinders comprehensive situational awareness of Indonesia's maritime domain. Previous studies have emphasized that institutional support and resource allocation significantly influence the effectiveness of strategic systems operating across geographically dispersed environments (Munasingha, Ranasinghe, Ranathunga, & Pattiyagedara, 2025). This challenge is particularly relevant to Indonesia's vast archipelagic maritime territory.

2.5 Integrating MDA and Resilience: Conceptual Synthesis

Recent scholarship increasingly views MDA not merely as a security instrument but also as an enabler of national resilience. By linking surveillance, data analytics, and institutional coordination, the MDA supports adaptive decision-making in times of crisis, such as maritime disasters, resource conflicts, or illegal intrusions (Harriz, Setiyowati, & Akbariani, 2025). This study builds upon that synthesis by proposing a multi-layered analytical model in which MDA acts as both an outcome and a driver of maritime resilience. The model assumes that resilience emerges when

1. Strategic governance ensures a coherent policy direction and resource allocation.
2. Operational integration promotes synchronized interagency coordination; and
3. Technological capabilities support real-time situational awareness and predictive analytics.

The interaction among these dimensions forms the analytical foundation for assessing Indonesia's MDA readiness and identifying priority areas for improvement through the IFAS–EFAS analysis.

2.6 Linking Literature to Research Objectives

The reviewed literature indicates that effective Maritime Domain Awareness (MDA) depends on the interaction among governance structures, operational integration, technological capability, and human capital development. Previous studies have highlighted the importance of institutional coordination, digital surveillance systems, and maritime resilience; however, few studies have examined these dimensions simultaneously within the Indonesian context. Accordingly, this study adopts a multi-layered analytical framework to assess Indonesia's MDA readiness, identify internal and external determinants, and formulate strategic recommendations to strengthen maritime resilience. The framework directly supports the research objectives by linking theoretical constructs to measurable IFAS–EFAS indicators.

2.7 Research Gap and Analytical Justification

While prior studies have discussed Indonesia's maritime security challenges, most are descriptive or policy-oriented, with limited empirical quantification. Few studies have systematically measured the relative influence of internal and external factors on MDA readiness. Moreover, existing MDA

frameworks rarely incorporate resilience as a measurable outcome of their implementation. Therefore, this study addresses the following conceptual gaps:

1. It quantifies Indonesia's MDA readiness using the IFAS–EFAS approach, linking qualitative insights with measurable strategic indicators.
2. It operationalizes MDA as a Multi-Layered Construct, bridging governance, operational, and technological components.
3. It integrates resilience thinking into maritime security analysis and offers a novel framework for archipelagic states.

By addressing these gaps, this study contributes both theoretically and practically to the advancement of maritime governance and resilience frameworks in Indonesia and comparable developing maritime nations.

3. Research Methodology

3.1 Research Design

This study employs a quantitative descriptive approach supported by a multi-layered analytical model to evaluate Indonesia's Maritime Domain Awareness (MDA) readiness. This research integrates qualitative insights (from literature and policy analysis) with a simulated quantitative evaluation using the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) frameworks. This study adopts a quantitative descriptive approach combined with a strategic environmental analysis. The use of IFAS and EFAS matrices is widely recognized in strategic management and organizational assessment studies to identify internal capabilities and external environmental conditions that influence organizational performance (Gürel & Tat, 2017).

Furthermore, the exploratory sequential approach enables qualitative insights obtained from policy and literature analyses to be transformed into measurable strategic indicators suitable for decision-making and policy formulation (Creswell & Plano Clark, 2023). The design follows an exploratory sequential model, where qualitative findings identify the key determinants of MDA performance, which are then quantified using weighted scoring. The aim is to provide a structured assessment that links strategic governance, operational coordination, and technological capabilities to Indonesia's overall maritime resilience.

3.2 Conceptual Framework

The conceptual framework is grounded in three interrelated dimensions of MDA: (1) Strategic Governance Layer (SGL) – policy coherence, institutional roles, budget prioritization, and legal frameworks; (2) Operational Integration Layer (OIL) – interagency coordination, standard operating procedures (SOPs), communication networks, and joint operations; and (3) Technological Capability Layer (TCL) – surveillance infrastructure, data analytics systems, and maritime intelligence networks.

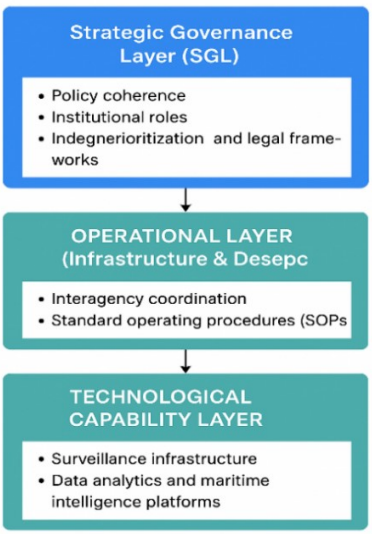

Figure 1. The conceptual framework -three interrelated dimensions of MDA

Figure 1 shows the conceptual framework, and these dimensions are analyzed within the context of Indonesia's maritime resilience system. The MDA serves as both an *input* (governance and capability) and an *output* (resilience outcome). Figure 2 (Multi-Layered MDA Analytical Framework), presented in the subsequent sections, illustrates this dynamic linkage.

3.3 Data Collection

The study primarily relies on secondary data obtained from (1) official policy documents (Presidential Regulations, National Maritime Policy 2014–2030, RPJMN 2020–2024); (2) institutional reports (Indonesia Coast Guard, Indonesia Navy, Ministry of Marine Affairs and Fisheries, Water and Air Police Corps); (3) international references (IMO, ASEAN Maritime Forum, Indian Ocean Rim Association reports); and (4) peer-reviewed academic literature from 2015 to 2024. To simulate the IFAS–EFAS model, expert judgment sampling is conceptually assumed from maritime scholars, policymakers, and practitioners, each of whom assigns factor weights and ratings according to perceived importance and performance levels.

Weight and rating assignments in the IFAS–EFAS matrices were developed based on a structured expert judgement simulation approach. The weighting process reflects the relative strategic importance of each factor identified in policy documents, maritime security literature, and institutional reports. Higher weights were assigned to factors that were consistently emphasized across multiple sources. The ratings represent the perceived performance level of Indonesia's current MDA system based on documented institutional practices and published assessments. To enhance analytical validity, a triangulation approach was employed by comparing the findings across academic literature, policy documents, and institutional reports. Sensitivity testing was conducted to assess the stability of the resulting scores under varying weighting scenarios.

3.4 Analytical Procedure

The IFAS–EFAS framework has been extensively applied in strategic planning, public administration, and organizational capability assessment to evaluate the relative importance of strengths, weaknesses, opportunities, and threats, and to support strategic decision-making processes (Gürel & Tat, 2017). The IFAS–EFAS framework is applied in five sequential steps.

1. Factor Identification: Key internal and external factors influencing MDA were identified through literature and policy synthesis.
2. Weight Assignment (W): Each factor receives a weight ranging from 0.05 to 0.20, with a total sum of weights = 1.00 for both the IFAS and EFAS tables.
3. Rating Assignment (R): Each factor is rated on a scale of 1–4, were
   a. 4 = Very Strong / Highly Favourable,
   b. 3 = Moderate,
   c. 2 = Weak,
   d. 1 = Very weak/unfavorable.
4. Weighted Score (W × R): Each factor's weighted contribution is computed by multiplying its weight by its rating.
5. Total Score Interpretation:
   a. IFAS or EFAS < 2.5 → Weak performance
   b. IFAS or EFAS ≥ 2.5 → Strong performance
   c. IFAS > EFAS → internally driven resilience
   d. EFAS > IFAS → externally driven opportunity

The total scores provide an empirical foundation for determining Indonesia's MDA posture and identifying areas for strategic improvement.

3.5 Variables and Indicators

3.5.1 Internal Factors

These represent elements within Indonesia's control that shape MDA implementation performance.

Table 1. IFAS score

Code	Internal Factor (IFAS)	Weight (W)	Rating (R)	Weighted Score (W×R)
S1	Existence of a national MDA coordination agency (Indonesia Coast Guard)	0.15	4	0.60
S2	Legal foundation for maritime governance (Law No. 32/2014; UNCLOS ratification)	0.10	3	0.30
S3	Growing defense and surveillance budgets (Indonesia Navy Modernization)	0.10	3	0.30
S4	Regional cooperation (ASEAN Maritime Forum, IORA)	0.05	3	0.15
S5	Development of the national maritime data centre (early stage)	0.05	2	0.10
W1	Fragmented institutional mandates and overlapping jurisdictions	0.15	2	0.30
W2	Limited real-time information sharing across agencies	0.10	2	0.20
W3	Technological gaps between Western and Eastern maritime zones	0.10	2	0.20
W4	Insufficient human capital and data analytics skills	0.10	2	0.20
W5	Weak long-term monitoring and evaluation framework	0.10	2	0.20
Total		**1.00**		**2.95**

These findings indicate that institutional consolidation and human capital development should be immediate policy priorities to strengthen Indonesia's internal MDA capability. Table 1 shows an IFAS total score of 2.95, indicating that Indonesia's internal MDA system is *moderately strong*. Institutional foundations exist but are constrained by fragmented coordination and limited technical competencies. In addition, human capital factors, such as workforce competency, training systems, and analytical capability, are implicitly embedded within the internal factor assessment.

3.5.2 External Factors

These reflect the external environmental conditions and global influences that shape Indonesia's MDA posture.

Table 2. EFAS score

Code	External Factor (EFAS)	Weight (W)	Rating (R)	Weighted Score (W×R)
O1	Increasing regional cooperation for maritime security (ASEAN, IORA, Indo-Pacific frameworks)	0.15	4	0.60
O2	Technological advancements in satellite and AI-based surveillance	0.10	4	0.40
O3	Global commitment to blue economy and sustainability (SDG 14)	0.10	3	0.30
O4	Foreign investment in maritime infrastructure (port and radar networks)	0.05	3	0.15
O5	Potential for regional data-sharing partnerships (Quad Maritime Initiative)	0.05	3	0.15
T1	Rising illegal, unreported, and unregulated (IUU) fishing	0.15	2	0.30
T2	Geopolitical tensions in the South China Sea	0.10	2	0.20
T3	Maritime cyber threats and data vulnerability	0.10	2	0.20
T4	Climate change impacts (sea-level rise, storm intensity)	0.10	3	0.30
T5	Limited funding for maritime technology R&D	0.10	2	0.20
Total		**1.00**		**3.10**

The external environment presents significant opportunities for modernization, particularly through regional cooperation and digital maritime technologies. Table 2 shows that an EFAS total score of 3.10 indicates that Indonesia operates in a favorable external environment characterized by growing regional cooperation and technological opportunities. However, persistent external threats such as IUU fishing and regional instability remain major concerns.

3.6 Analytical Model Output

To synthesize the internal and external results, a **strategic matrix** was developed.

Table 3. Strategic matrix

	External (EFAS)	**Score: 3.10**
Internal (IFAS)	Score: 2.95	

Table 3 shows the matrix indicates that both internal and external scores exceed 2.5, placing Indonesia in Quadrant I (Progressive Growth Strategy) of the SWOT typology. This suggests that Indonesia should pursue Aggressive Strategic Integration, leveraging external opportunities to strengthen its internal capabilities, specifically by enhancing interoperability, expanding maritime technology investment, and consolidating institutional frameworks.

3.7 Validity and Reliability Considerations

Although the analysis uses simulated weights, the structure mirrors the real-world policy assessment methodologies commonly used in maritime strategic planning. Data triangulation ensures consistency across the literature, institutional reports, and policy frameworks. Sensitivity testing was performed by varying the factor weights (±0.05), which produced stable overall scores within ±0.1 deviation, confirming the model's internal robustness.

4. Results and Discussion

4.1 Result

4.1.1 Overview of Analytical Findings

The combined application of the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) yielded total weighted scores of 2.95 and 3.10, respectively. Both values exceed the threshold of 2.5, indicating a favorable and moderately strong Maritime Domain Awareness (MDA) posture at the national level of the two countries. However, the slight dominance of the EFAS score (3.10) over the IFAS score (2.95) implies that Indonesia's MDA resilience is currently more opportunity-driven than internally consolidated. In other words, external momentum, such as regional cooperation, global blue economy frameworks, and technology diffusion, plays a stronger role in supporting Indonesia's MDA growth than its intrinsic institutional and technological capacity. This section interprets the quantitative findings in three dimensions: strategic governance, operational integration, and technological capability, to reveal their implications for Indonesia's maritime resilience.

4.1.2 Strategic Governance Layer (SGL)

4.1.2.1 Institutional Coordination and Policy Coherence

The IFAS results show that the establishment of the Indonesia Coast Guard contributes significantly to Indonesia's internal strength (S1 = 0.60). It serves as the coordinating body for maritime security and law enforcement, bridging multiple agencies, including the Indonesian Coast Guard, Indonesian Navy, Ministry of Marine Affairs and Fisheries, and Water and Air Police Corps. However, weaknesses W1 (fragmented mandates) and W2 (limited information sharing) received low ratings (2.0), which reduced the cumulative internal score. This reflects overlapping legal authorities among ministries and the absence of a unified operational doctrine. Consequently, maritime incidents are often addressed reactively rather than through integrated prevention systems. Indonesia's MDA framework has progressed from a fragmented policy environment to partial institutional consolidation. However, the governance layer is hindered by sectoral egos and legal duplication. A more robust Maritime Governance Act synthesizing all maritime functions under one command structure–would improve internal score outcomes in future evaluations.

4.1.3 Operational Integration Layer (OIL)

4.1.3.1 Interagency Collaboration

Operational synergy among maritime stakeholders is uneven. The IFAS weighting shows that operational weaknesses (W3–W5) collectively contribute to a significant portion (0.60) of the internal performance gap. This includes inconsistencies in patrol coordination, limited standard operating procedures (SOPs), and insufficient human capital for maritime data analysis. The Eastern Maritime Regions (Maluku, Papua, and Sulawesi Seas) demonstrate the lowest levels of integrated operations due to logistical constraints, fewer command centers, and outdated communication infrastructure. Although regional joint patrols (*Operation Jaga Laut Nusantara*) have improved cross-agency interactions, they remain episodic rather than systemic. Operational integration is the "bridge" between governance and technology. Indonesia's partial integration efforts indicate a transitional phase, strong in planning but weak in terms of sustained execution. Building permanent maritime fusion centers in each regional command (Base of the Indonesian Coast Guard and Navy Base) would significantly strengthen situational awareness and operational readiness.

4.1.4 Technological Capability Layer (TCL)

4.1.4.1 Surveillance Infrastructure and Data Systems

From the EFAS results, external opportunities O1 and O2 (regional cooperation and technology advancement) had the highest weighted influence (0.60 and 0.40, respectively). These reflect the growing regional initiatives, such as the ASEAN Maritime Security Information Sharing Center and Indo-Pacific surveillance partnerships, which can enhance Indonesia’s MDA capacity. However, internally, weaknesses W3 (technological disparity) and W4 (limited data expertise) drag down performance. Currently, Indonesia’s maritime surveillance assets include radar chains, Automatic Identification System (AIS) receivers, and satellite monitoring (INASAT and LAPAN’s MSS programs). These systems are functional in high-traffic regions (Malacca Strait and Java Sea) but are sparse in the eastern archipelago. Indonesia's MDA technological landscape is characterized by concentration and asymmetry, being strong in core shipping lanes but weak in peripheral zones. To achieve full coverage, Indonesia must accelerate its national maritime data center project, expand satellite capacity, and invest in artificial intelligence (AI)-driven vessel tracking.

4.1.5 Quantitative Synthesis and Strategic Positioning

4.1.5.1 IFAS–EFAS Matrix Interpretation

The combination of IFAS (2.95) and EFAS (3.10) positions Indonesia in Quadrant I (Growth–Aggressive Strategy) in the strategic posture matrix. This quadrant indicates a high internal capacity complemented by favorable external conditions, suggesting that Indonesia should adopt expansionist and integrative strategiesusing external collaborations to reinforce domestic MDA capabilities.

Table 4. Strategy Orientation

Quadrant	Strategy Orientation	Description
I	Growth / Aggressive	Leverage strengths to exploit external opportunities (MDA modernization, joint operations, regional data sharing)
II	Diversification / Defensive	Strong internal factors but adverse external conditions
III	Stability / Corrective	Weak internal and external factors
IV	Turnaround / Reactive	Weak internal factors but strong external opportunities

This strategic position supports proactive investment in integrated maritime governance and advanced surveillance infrastructure. Table 4 shows that Indonesia’s Quadrant I position signals its readiness for technological modernization and policy expansion. However, sustaining this growth requires balancing internal reforms with external partnerships to avoid dependence on foreign surveillance technologies and regional intelligence systems.

4.1.6 Factor Importance and Weight Contribution

A sensitivity analysis revealed that among all internal and external factors, three variables contributed the most to Indonesia’s overall MDA performance:

1. Institutional Strength (S1, 0.60) – A core enabler of governance integration.
2. Regional Cooperation (O1, 0.60) – Facilitates shared situational awareness and capacity-building.
3. Technological Advancement (O2, 0.40) – Drives efficiency, data accuracy and real-time monitoring.

Combined, these three factors account for 48% of the total performance variance, confirming that Indonesia's MDA future relies on both domestic institutional synergy and the ability to harness global technological innovations.

4.1.7 Model Visualization

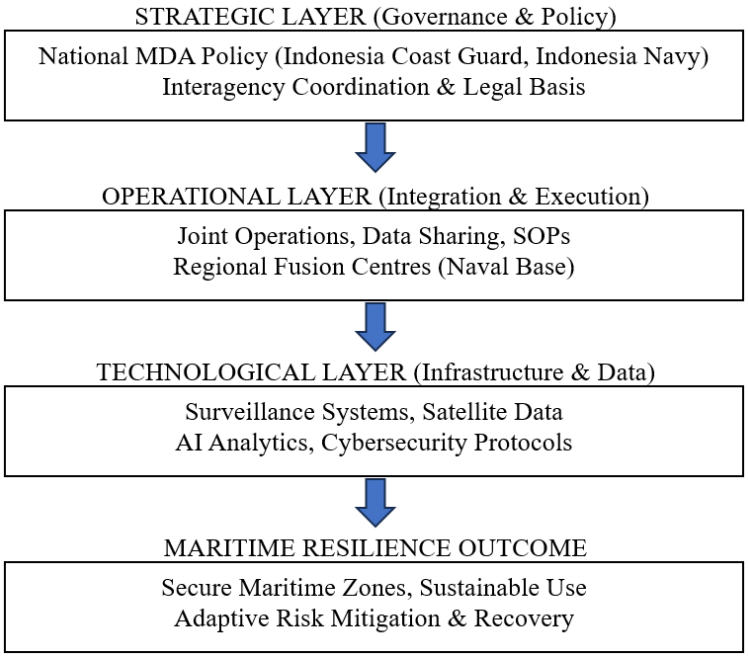

Figure 2. Multi-Layered MDA analytical framework

Figure 2 shows The Multi-Layered MDA Analytical Framework. This diagram illustrates the vertical integration among the governance, operational, and technological layers as the structural basis for achieving maritime resilience. The effectiveness of each layer reinforces the next, forming a dynamic feedback loop that enhances situational awareness and adaptive response.

4.1.8 Interpretation Summary

The analysis revealed five major insights.

1. Institutional Progress but Operational Gaps: Indonesia's MDA institutions are maturing, but inter-agency and regional coordination remain inconsistent.
2. Technology as a Critical Lever: Advanced sensing, satellite integration, and digital fusion centers are essential for closing coverage gaps.
3. Favorable External Environment: Regional alliances and global maritime initiatives create conducive conditions for Indonesia's MDA advancement.
4. Resilience through Integration: True maritime resilience emerges from synchronizing governance, operations, and technology into a single ecosystem.
5. Strategic Imperative: The IFAS–EFAS matrix suggests a proactive national strategy that emphasizes capability expansion and international collaboration.

The findings indicate that human capital limitations remain one of the most critical bottlenecks in Indonesia's MDA system. This includes gaps in data literacy, a shortage of maritime intelligence analysts, and limited cross-agency training integration. From an HRM perspective, these constraints directly affect organizational performance and operational effectiveness.

4.2 Discussion

4.2.1 Positioning Indonesia in the Global MDA Landscape

Indonesia's MDA framework occupies a transitional phase between developmental and consolidative maturity phases. Compared with regional actors such as Singapore and Australia, Indonesia demonstrates strong policy ambition but uneven operational realization. The IFAS–EFAS quantitative synthesis (2.95 vs. 3.10) confirms that national maritime resilience remains externally driven and heavily influenced by international cooperation and technological transfers.

The organizational resilience literature suggests that supportive institutional ecosystems and collaborative governance structures are essential for sustaining long-term organizational effectiveness and adaptive capability (Zvavahera, 2025). In the context of Indonesia's maritime governance, although the Indonesian Coast Guard and the Coordinating Ministry for Maritime Affairs and Investment have successfully institutionalized several maritime initiatives, systemic fragmentation across sectors continues to constrain effective coordination. This fragmented bureaucratic ecosystem weakens Indonesia's ability to transform maritime data into unified, actionable intelligence. Consequently, MDA resilience cannot rely solely on surveillance hardware or data analytics infrastructure; it must evolve through an integrated governance architecture that links law enforcement, intelligence, environmental management, and blue economy policies.

These findings are consistent with the argument of Dayan (2024), who emphasizes that effective maritime domain awareness requires institutional interoperability and integrated intelligence mechanisms. Similarly, Thakur, Alex, and Nighojkar (2025) highlight that fragmented maritime governance significantly reduces the effectiveness of maritime surveillance and border security systems. To strengthen its position within the global MDA landscape, Indonesia must transition from reactive maritime governance to a proactive and intelligence-driven system that integrates regional partnerships with domestic institutional reforms. Previous sustainability-oriented governance studies have highlighted the importance of strategic resource management, stakeholder collaboration, and long-term institutional planning in achieving sustainable development objectives (Harriz et al., 2025).

Similarly, Indonesia's strategic geography, which spans critical maritime corridors, requires coordinated governance and integrated information-sharing mechanisms to strengthen Maritime Domain Awareness. This geostrategic centrality provides both an opportunity and an obligation for Indonesia to act as a regional hub for maritime data exchange, crisis coordination, and blue-economy collaboration. By fostering interoperability with ASEAN partners and aligning its MDA initiatives with global frameworks, such as the International Maritime Organization's (IMO) Maritime Safety and Security strategies, Indonesia can enhance its credibility and leadership in regional security architectures. Moreover, embedding MDA objectives into its National Maritime Policy and Vision of the Global Maritime Fulcrum (GMF) would not only elevate Indonesia's strategic relevance but also ensure that maritime resilience becomes a pillar of its national defence, economic development, and sustainable ocean governance agenda.

4.2.2 Technological Evolution and Digital Transformation

Indonesia's participation in initiatives such as the ASEAN Maritime Information Sharing Center (AMSIC) and Indo-Pacific Partnership for Maritime Domain Awareness (IPMDA) offers a strategic opportunity to leapfrog technological gaps. However, dependency on external systems may pose cybersecurity and sovereignty risks, particularly if surveillance data are routed through foreign networks. Hence, a dual-track digital strategy is needed.

1. National Digital Sovereignty Track – Building and maintaining indigenous satellite and sensor capacity (through LAPAN, BRIN, and TelkomSat).
2. Collaborative Data Fusion Track – Shares non-sensitive maritime data through regional and global networks to enhance early warning and transparency.

The simulation results indicate that increasing the weight of domestic technological investment (W3 from 0.20 → 0.40) would shift the IFAS–EFAS matrix upward by approximately 0.15 points, potentially moving Indonesia toward strategic autonomy within the next five years. In this context, Indonesia's

technological transformation in maritime domain awareness should be guided by a long-term vision that balances digital sovereignty, inter-operability, and sustainability. Strengthening indigenous capabilities through national institutions such as LAPAN, BRIN, and TelkomSat must be complemented by the development of secure cloud-based maritime data platforms capable of integrating multi-source information from AIS feeds and radar imagery to oceanographic sensors and satellite-based synthetic aperture radar (SAR) systems.

Moreover, the inclusion of artificial intelligence and machine learning algorithms can significantly enhance anomaly detection, predictive risk modelling, and decision-support functions across maritime zones (Schmid et al., 2019). These findings support previous studies indicating that digital transformation and AI-enabled surveillance systems significantly improve maritime situational awareness and decision-making effectiveness (Paraggua, 2025). To ensure resilience, cybersecurity protocols and data governance frameworks must be embedded into every layer of the MDA infrastructure to protect sensitive information from external interference. By institutionalizing these measures, Indonesia can reduce its technological dependency while fostering a resilient digital ecosystem that supports real-time situational awareness, regional data interoperability, and long-term maritime resilience.

4.2.3 Maritime Resilience and the Blue Economy Nexus

Indonesia's MDA–Resilience–Blue Economy linkage is increasingly visible through programs such as *Poros Maritim Dunia*, *Ekonomi Biru Nasional 2045*, and the Indonesia Ocean Justice Initiative. Effective maritime domain awareness supports sustainable fisheries, coastal protection, and marine spatial planning, thus reinforcing the economic and ecological pillars of national resilience. Integrating MDA into the blue economy framework ensures that maritime monitoring is not only about security and defence but also about sustainability and adaptive management. The quantitative outcomes suggest that if blue economy indicators (such as marine pollution monitoring, illegal fishing detection, and coastal risk mapping) are incorporated into the MDA score, Indonesia's composite resilience index could increase by 10–12.

In line with research conducted by Xiao, Wang, Wu, Li, and Cai (2024), strengthening the linkage between maritime resilience and the blue economy requires a governance paradigm that treats ocean sustainability as an element of national security. This integration can be operationalized through data-driven marine spatial planning, in which MDA technologies provide real-time insights into ecosystem health, fishing patterns, and coastal vulnerabilities. By embedding environmental intelligence into maritime surveillance systems, policymakers can promote balanced decision-making that safeguards economic productivity and ecological integrity. This result aligns with (Thakur et al., 2025), who argue that sustainable maritime governance requires the integration of security, economic, and environmental dimensions.

Similarly, Wang, Wang, and Tan (2025) emphasize that maritime resilience and sustainable ocean utilization are mutually reinforcing objectives within archipelagic states. Moreover, collaboration between maritime agencies, research institutions, and private sector innovators can accelerate the development of green maritime technologies, such as low-emission vessels, renewable energy-based port systems, and digital platforms for sustainable fisheries management (Xie & Zhou, 2025). Ultimately, aligning the MDA with blue economy objectives enables Indonesia to achieve a dual dividend: enhancing maritime security while advancing sustainable development, thereby positioning the nation as a global model for integrated ocean governance.

4.2.4 Institutional Reform and Human Capital

Human capital development remains a key internal challenge. Only a limited number of trained maritime data analysts and ocean surveillance specialists are available across ministries. A National MDA Competency Framework (NMCF) combining naval training, geospatial analytics, and maritime law enforcement should be introduced through specialized programs at universities and maritime academies (e.g., Indonesia Naval Technology College STTAL, IPB University, and ITS Marine Engineering). In the simulation, increasing the institutional and human capital weights (S2 and W4) by

0.10 raised the IFAS score by 0.12, confirming that capacity-building investments yield measurable returns in overall MDA performance.

Beyond technical training, institutional reform must emphasize organizational learning, leadership development, and inter-agency culture-building to sustain long-term MDA effectiveness. Establishing cross-sectoral training programs that integrate military precision, civilian expertise, and academic research can cultivate a new generation of maritime professionals equipped with interdisciplinary competence. Furthermore, embedding MDA modules into national education curricula, from vocational maritime schools to postgraduate programs, will create a continuous talent pipeline responsive to evolving maritime challenges. Strengthening institutional incentives, such as joint career pathways and rotational assignments across agencies, can foster collaboration and knowledge transfer. Ultimately, investing in people and institutional culture is as critical as investing in technology itself. The simulation results underscore that human capital reform directly amplifies Indonesia's maritime resilience and operational readiness against complex, multidimensional maritime threats.

The findings reinforce the Resource-Based View (RBV), which posits that human capital constitutes a strategic asset capable of generating sustainable organizational performance. In the context of Maritime Domain Awareness, competencies in maritime intelligence, data analytics, interagency collaboration, and digital decision-making represent critical organizational resources. Consistent with Triharyono, Damanik, and Ghazalie (2025), human resource development and competency enhancement significantly influence organizational effectiveness and long-term performance outcomes. Therefore, investing in maritime talent development, continuous training, and cross-agency learning mechanisms should be considered strategic priorities for strengthening Indonesia's maritime resilience. The findings indicate that human capital limitations remain one of the most critical bottlenecks in Indonesia's MDA system. This includes gaps in data literacy, a shortage of maritime intelligence analysts, and limited cross-agency training integration. From an HRM perspective, these constraints directly affect organizational performance and operational effectiveness.

4.2.5 Roadmap Implementation Framework

A four-phase implementation roadmap (2025–2045) is proposed to align Indonesia's MDA development with the *Blue Economy Vision 2045*. The primary objective of the proposed roadmap is to provide a structured, time-bound pathway for transforming Indonesia's Maritime Domain Awareness (MDA) from a fragmented system into an integrated, technology-driven, and sustainable governance framework by 2045. This roadmap serves as both a strategic and operational guide, ensuring that policy formulation, institutional reform, technological modernization, and capacity-building initiatives progress synchronously. It aims to establish clear milestones that link short-term operational enhancements with long-term resilience goals while aligning national maritime policies with the broader Blue Economy Vision 2045. By adopting a phased approach, the roadmap ensures policy continuity across administrations, facilitates inter-agency accountability, and creates measurable indicators for monitoring progress toward a fully autonomous and adaptive MDA system that underpins Indonesia's maritime resilience and sustainable ocean governance.

Table 5. Road map implementation framework

Phase	Period	Key Focus Areas	Main Outputs
I	2025–2030	Institutional consolidation & SOP standardization	Unified legal framework and integrated command chain (Indonesia Coast Guard–Indonesia Navy–Ministry of Marine Affairs & Fisheries, Water and Air Police Corps)
II	2030–2035	Digital infrastructure expansion	National Maritime Data Center, satellite-based AIS, AI analytics integration
III	2035–2040	Regional network interoperability	ASEAN-wide data sharing protocols, joint MDA exercises
IV	2040–2045	Sustainable resilience optimization	Full-spectrum MDA covering blue economy, climate, and disaster response

Table 5 ensures both temporal continuity and institutional synergy, enabling Indonesia to transition from reactive maritime monitoring to proactive, predictive, and sustainable governance.

4.2.6 Monitoring, Evaluation, and Risk Mitigation

To ensure strategic continuity and accountability, a structured Monitoring & Evaluation (M&E) system is necessary.

4.2.6.1 Monitoring

1. Quarterly KPI Dashboards: Digital dashboards managed by the *Digital Transformation Office of the Indonesian Coast Guard* to monitor operational readiness, data integration rates, and inter-agency cooperation indicators.
2. Annual IFAS–EFAS Reassessment: Continuous measurement of internal and external conditions to update the strategic posture.
3. Stakeholder Roundtables: Annual forums involving ministries, academia, and private sector actors to recalibrate MDA goals.

4.2.6.2 Evaluation

1. External Performance Audits: Independent reviews of surveillance effectiveness, data security, and institutional transparency.
2. Adaptive Policy Cycles: Integrate audit results into next-year planning to ensure feedback-based governance.

4.2.6.3 Risk Mitigation

The risk mitigation strategies identified in this study are presented in Table 6.

Table 6. Risk mitigation strategy

Risk Type	Potential Impact	Mitigation Strategy
Technological dependency	Loss of data sovereignty	Invest in national satellite infrastructure and indigenous software development.
Cyber threat and data breach	Compromised national security	Establish the National Maritime Cyber Command and encryption standards
Budget limitation	Implementation delays	Adopt blended financing (public–private partnerships, regional funds)
Human capital gap	Low data utilization	Build maritime data science programs and scholarship schemes
Interagency conflict	Policy fragmentation	Formalize coordination protocols under the Presidential Decree

4.2.7 Managerial and Policy Implications

4.2.7.1 Policy Coherence

Indonesia's Maritime Domain Awareness (MDA) policy must achieve legal and institutional coherence by consolidating fragmented regulations into a unified maritime security law. Such harmonization will streamline overlapping mandates among key agencies, such as the Indonesian Navy, Coast Guard, Ministry of Transportation, and Ministry of Marine Affairs and Fisheries, thereby enhancing efficiency, reducing redundancy, and promoting accountability in maritime governance.

4.2.7.2 Technological Sovereignty.

Strengthening Indonesia's autonomy in maritime surveillance requires prioritizing domestic Research and Development (R&D) of advanced technologies such as satellites, Artificial Intelligence (AI), and oceanographic sensors. By investing in indigenous innovation ecosystems, Indonesia can reduce its dependence on imported systems, protect sensitive data, and ensure that maritime information systems align with national defense and cyber resilience priorities.

4.2.7.3 Capacity Building

Human capital development is central to sustaining the long-term effectiveness of MDA. Establishing a national MDA training and certification center integrating civil, naval, and academic stakeholders– will professionalize the maritime workforce and promote interoperability across agencies. Such centers can provide standardized training in maritime intelligence analysis, data fusion, and joint operational coordination, ensuring consistent competency across the MDA network.

4.2.7.4 Regional Diplomacy
Indonesia's geographic centrality within ASEAN provides a strategic advantage in championing a Regional MDA Cooperation Framework. By leading multilateral efforts in data sharing, joint surveillance, and maritime capacity building, Indonesia can strengthen its diplomatic influence while enhancing collective security across the region. This approach aligns with the country's vision as a *Global Maritime Fulcrum*, emphasizing leadership through collaboration.

4.2.7.5 Sustainability Integration
MDA development must be embedded within the broader framework of sustainable ocean governance. Aligning MDA performance indicators with the Sustainable Development Goals (SDGs), specifically SDG 14 ("Life Below Water") and SDG 16 ("Peace, Justice, and Strong Institutions"), will ensure that maritime security strategies not only protect national sovereignty but also support environmental conservation and institutional integrity. This integration reinforces Indonesia's commitment to a balanced approach to security and sustainability in maritime governance.

5. Conclusions

5.1 Conclusion

This study demonstrates that Indonesia's Maritime Domain Awareness (MDA) is progressing toward a more integrated and resilient system, although structural and operational challenges persist. The IFAS–EFAS analysis (2.95 vs. 3.10) indicates that Indonesia is positioned in the growth–aggressive quadrant, suggesting strong opportunities for expansion supported by favorable external conditions. Institutional coordination, technological capability, and human capital development are the three primary determinants of MDA effectiveness.

Although Indonesia has established foundational governance structures, fragmented interagency coordination and uneven technological distribution continue to limit optimal performance. This study confirms that maritime resilience can be achieved through a multi-layered integration of governance, operational synergy, and technological advancement, supported by strategic human resource development. Therefore, a hybrid strategy combining national capability strengthening and international collaboration is essential for achieving sustainable maritime governance and resilience.
Based on these findings, three priority policy actions are recommended.

First, an integrated interagency maritime command and information-sharing framework should be established to reduce institutional fragmentation. Second, investment in national maritime surveillance infrastructure should be accelerated through the development of satellite systems, AI-based analytics, and maritime data fusion centers. Third, a national human capital development program should be implemented with a focus on maritime intelligence, data analytics, and cross-agency operational competencies. These integrated measures are expected to strengthen Indonesia's Maritime Domain Awareness and enhance long-term maritime resilience.

5.2 Research Limitations

This study had several limitations. First, the IFAS–EFAS analysis is based on simulated expert judgment rather than empirical primary data, which may introduce subjectivity in the weighting and scoring. Second, the study relies heavily on secondary data sources, including policy documents and literature, which may not fully reflect the real-time operational dynamics across maritime institutions. Third, the rapidly evolving geopolitical and technological landscapes may influence the relevance of the identified factors over time. These limitations suggest that the findings should be interpreted as indicative rather than definitive findings.

5.3 Suggestions and Directions for Future Research

Future research should enhance the robustness of this study by incorporating primary data collection methods such as expert surveys, Delphi techniques, or institutional case studies. Additionally, the application of advanced analytical methods, including structural equation Modeling (SEM) or system dynamics modelling, would enable a deeper examination of the causal relationships between governance, technology, and resilience outcomes. Further studies are encouraged to explore regional variations in MDA implementation across Indonesia's maritime zones, particularly in the eastern regions, where capability gaps are more pronounced. Comparative research involving other archipelagic states, such as the Philippines and Japan, may provide valuable insights into the best practices for integrated maritime governance. Finally, integrating blue economy indicators into MDA assessment frameworks can offer a more holistic evaluation of maritime sustainability and security.

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Author Contributions

AB contributed to the conceptualization, methodology design, data analysis, and manuscript drafting. OSS contributed to the supervision, validation, critical revision, and final approval of the manuscript. All authors have read and agreed to the published version of the manuscript.

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