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Strategic governance for hybrid maritime threats: A hexa-helix model approach

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ABSTRACT

Background: Indonesia's eastern maritime region, despite its immense geostrategic importance, faces persistent defense infrastructure gaps, limited naval presence, and fragmented policy implementation. This study aims to address these challenges by proposing the Hexa-Helix collaboration model as a strategic policy framework for maritime defense reinforcement. **Methods:** Employing qualitative strategic analysis and literature review, the research elaborates the evolution of innovation collaboration theory from the Triple Helix to a novel Hexa-Helix model tailored to the archipelagic defense context. **Findings:** Findings indicate that existing maritime defense efforts in Eastern Indonesia are hindered by underdeveloped naval infrastructure, limited local shipbuilding industries, and weak stakeholder integration. The Hexa-Helix model incorporates six key actors: government, navy, academia, industry, society, and media to establish a more inclusive and adaptive defense ecosystem, particularly in high-risk zones such as the Sulu Sea. **Conclusion:** This study concludes that the Hexa-Helix collaboration model provides an effective governance framework for addressing hybrid maritime threats by integrating defense, innovation, and public engagement across key stakeholders. The model strengthens maritime security and institutional resilience in archipelagic regions facing complex transboundary challenges. **Novelty/Originality of this article:** The novelty of this study lies in institutionalizing the Navy and media as independent helices, expanding conventional innovation frameworks to address hybrid threats in maritime border areas. The model offers strategic pathways for enhancing Indonesia's maritime sovereignty and fostering sustainable local defense industry growth.

KEYWORDS: hexa-helix; maritime defense; strategic policy.

1. Introduction

Indonesia is the world's largest archipelagic state, consisting of over 17,000 islands stretching across the Indian and Pacific Oceans and positioned strategically between the continents of Asia and Australia. This unique geography places Indonesia at the center of global maritime trade routes and establishes its role as a maritime fulcrum within the Indo-Pacific region (Arifin et al., 2024). With the second-longest coastline in the world and an Exclusive Economic Zone (EEZ) exceeding 6 million square kilometers, Indonesia possesses extraordinary maritime potential both in terms of natural resources and geopolitical significance. Accordingly, the maritime domain has become a foundational pillar not only for national economic development but also for Indonesia's defense and security posture.

The Indonesian government has promoted the vision of the "Global Maritime Fulcrum" (*Poros Maritim Dunia*) to restore its historical maritime legacy, emphasizing inter-island

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connectivity, marine resource protection, and the development of naval defense capabilities (Arifin et al., 2024). However, the implementation of this agenda remains structurally uneven. Maritime development and naval infrastructure investments are heavily concentrated in the western regions of Indonesia, such as Java and Sumatra, while eastern provinces like Maluku, Papua, and Sulawesi suffer from critical infrastructure deficits, human resource constraints, and institutional inefficiencies (Sari et al., 2022). These disparities not only hinder regional development but also compromise national maritime integration and defense preparedness in areas highly vulnerable to transnational threats.

The geographic concentration of Indonesian navy infrastructure is not merely an administrative oversight; it constitutes a structural vulnerability embedded within Indonesia's national defense architecture. Table 1 presents a comprehensive mapping of Indonesian navy infrastructure distribution across all major operational and support categories. The data reveal a pronounced and systematic concentration of strategic naval assets in western Indonesia, particularly in Java and the Riau Islands, while the central and eastern maritime zones remain critically underserved. Of the twenty major infrastructure installations documented, sixteen (80%) have their primary or exclusive presence in western Indonesia, with only four installations maintaining any significant presence in central or eastern regions (TNI AL, 2024).

Table 1. Comprehensive distribution of Indonesian Navy infrastructure

Category	Name Type of Infrastructure	Primary Location	Regional Concentration
Main Command (Fleet)	*Komando Armada Republik Indonesia*/ Republic of Indonesia Fleet Command (Koarmada I)	Tanjung Uban, Riau Islands	Western Indonesia
Main Command (Fleet)	Koarmada II	Surabaya, East Java	Central Indonesia
Main Command (Fleet)	Koarmada III	Sorong, Southwest Papua	Eastern Indonesia
Main Naval Base (Lantamal)	14 Lantamale (I–XIV)	Belawan to Merauke	Distributed (West-dominant)
Naval Air Base (Lanudal)	Naval Aviation Units	Juanda, Biak, Manado, Tanjung Pinang	Western/Central
Maintenance Facility (Fasharkan)	Ship & Weapons Workshop	Surabaya, Manado, Ambon, Manokwari	Western Indonesia (Primary)
Special Infrastructure	Pushidrosal (Hydro-Oceanographic Center)	Jakarta (Ancol)	Western Indonesia
Special Infrastructure	Sea Transport Command	Jakarta (Tanjung Priok)	Western Indonesia
Education & Training	Naval Academy	Surabaya	Western Indonesia
Education & Training	Indonesian Navy Doctrine, Education and Training Development Command & Indonesian Navy Staff and Command College	Surabaya & Jakarta	Western Indonesia
Special Forces	Marine Corps HQ (Mako Korps Marinir)	Jakarta	Western Indonesia
Special Forces	Marine Force (*Pasukan Marinir*/*Pasmar*) 1, 2, & 3	Jakarta, Surabaya, Sorong	West-dominant
Special Forces	Frogman Commando/*Komando Pasukan Katak (Kopaska)* & Jalamangkara Detachment	Jakarta & Surabaya (Primary), Sorong (Unit)	West-dominant

	(Detasemen Jalamangkara) Denjaka Units		
Strategic Weaponry	Arsenal/Ammunition Center	Batuporon, Madura	Western Indonesia
Strategic Weaponry	Labinsen (Weapons Laboratory)	Surabaya	Western Indonesia
Specialist Health	Lakesla (Maritime Health Institute)	Surabaya	Western Indonesia
Specialist Health	Ladokgi (Naval Dentistry Institute)	Jakarta	Western Indonesia
Specialist Health	RSAL Level I (Naval Hospital)	Dr. Ramelan (Surabaya), Dr. Mintohardjo (Jakarta)	Western Indonesia
Operational Command	Puskodal (Command & Control Center)	Mabesal, Jakarta	Western Indonesia
Operational Command	Submarine Unit (Satsel)	Surabaya	Western Indonesia

(TNI-AL, 2024)

The implications of this distribution pattern are far-reaching. The most technologically sophisticated and operationally critical assets, including the Hydro-Oceanographic Center/ *Pusat Hidro-Oseanografi TNI Angkatan Laut* (Pushidrosal), the Sea Transport Command/*Komando Lintas Laut Militer* (Kolinlamil), the Naval Academy/*Akademi Angkatan Laut* (AAL), all specialist health institutions, the national ammunition arsenal, and the command-and-control nerve center/*Pusat Komando dan Pengendalian* (Puskodal), are exclusively located in western Indonesia. This means that any naval operation or emergency in eastern waters requires either the westward transfer of personnel for training, medical care, and maintenance, or the eastward deployment of assets over vast distances. The structural inefficiency created by this concentration directly undermines response times, operational readiness, and deterrence credibility in the very maritime zones where hybrid threats are most acute (Arifin et al., 2024; Dirhamsyah et al., 2022)

Eastern Indonesia is endowed with significant marine economic assets. Capture fisheries and aquaculture in the waters of Maluku and Papua contribute substantially to national fish production, while coastal areas of Sulawesi and East Nusa Tenggara offer untapped potential for marine renewable energy and world-class maritime tourism. Geopolitically, this region includes critical sea lines of communication such as the Banda Sea and Pacific Sea Lane, connecting the Indian and Pacific Oceans (Yang et al., 2025). The Sulu Sea, which borders the Philippines and Malaysia, stands out as one of the most strategic and high-risk maritime zones in Southeast Asia, serving as a corridor for transnational crimes, including armed robbery, illegal fishing, human trafficking, and arms smuggling (Ellettet al., 2025).

Despite Indonesia's participation in regional initiatives such as the Trilateral Cooperative Arrangement (TCA) with the Philippines and Malaysia since 2017, operational efforts have yet to address deeper structural gaps, particularly the underdeveloped defense industrial capacity in eastern Indonesia (Rustam et al., 2022). Reports by the International Maritime Bureau and national agencies continue to classify the Sulu Sea as a red zone due to persistent security risks. This situation underscores Indonesia's insufficient maritime surveillance, inadequate naval presence, and the lack of localized industrial support for defense logistics. Moreover, strategic doctrines such as the Minimum Essential Force (MEF) and the Indonesian Maritime Defense Doctrine remain disproportionately implemented in the western theater, leaving eastern maritime zones structurally unguarded (Arifin et al., 2024).

From a theoretical perspective, traditional state-centric defense frameworks have proven inadequate in responding to the hybrid nature of maritime threats in the 21st century, which are increasingly non-traditional, decentralized, and embedded within

civilian contexts (Carayannis & Preissler, 2025). Recent literature on collaborative innovation in security governance suggests the need for expanded multi-actor models. The evolution from the Triple Helix model (government, academia, and industry) to the Quintuple Helix (which adds civil society and media/environment) offers a foundation for rethinking defense governance through participatory and localized frameworks (Castellacci & Natera, 2013; Stephens, 2025).

Building on these theoretical advancements, this paper proposes a novel Hexa-Helix collaboration model specifically designed to enhance maritime defense industrial ecosystems in eastern Indonesia. The model institutionalizes six strategic actors: government, navy, academia, industry, civil society, and media. By formally recognizing the Indonesian Navy and media as independent helices, the model addresses gaps in operational readiness, public accountability, and innovation flows. This approach extends previous helix models by integrating applied defense knowledge and public communication dynamics into defense planning and industrial development (Hasibuan, 2021; Rochwulaningsih et al., 2019).

The objective of this study is to construct a strategic policy framework that strengthens Indonesia's maritime sovereignty through collaborative innovation tailored to the eastern region. Specifically, it aims to analyze the operational and structural gaps in maritime defense and to propose an inclusive governance model capable of catalyzing localized defense industry growth and adaptive security responses. The novelty of this research lies in formulating the Hexa-Helix model as a context-specific extension of existing innovation theories, bridging the scholarly gap between national defense planning and regional industrial autonomy. This study hypothesizes that the institutionalization of multi-actor collaboration particularly through the addition of military and media actors can significantly enhance the resilience and sustainability of Indonesia's maritime defense system in high-risk border zones.

2. Methods

This study adopts a qualitative policy analysis approach, combining conceptual elaboration, strategic literature review, and contextual mapping tailored to the maritime defense sector of Eastern Indonesia. The research methodology emphasizes an interpretive strategy that examines inter-institutional dynamics, policy gaps, and innovation networks through the lens of collaborative governance theory. It seeks to develop a strategic framework that operationalizes the Hexa-Helix collaboration model in a maritime defense context.

The core of this research lies in constructing the Hexa-Helix model through an iterative and integrative process, (1) a critical review of collaborative innovation frameworks such as the Triple Helix and Quintuple Helix; (2) contextualization of Indonesia's maritime threats and industrial defense posture; and (3) synthesis of governance models from defense policy and regional cooperation literature (Prasetyo et al., 2023). A special focus was placed on the Sulu Sea region, identified as a high-risk maritime zone due to its strategic location and presence of transnational security threats such as piracy, terrorism, and IUU fishing (Edyvane & Penny, 2017; Kadfak & Linke, 2021).

The data sources comprise peer-reviewed journals, Indonesian government white papers, naval strategic doctrine documents, and empirical case studies on multilateral maritime cooperation in Southeast Asia. The analysis framework includes: (a) actor-network mapping to identify roles and power dynamics among six helices; (b) capability gap assessment using qualitative indicators; and (c) integration modeling to test the theoretical applicability of Hexa-Helix to local defense systems. This triangulated method ensures analytical robustness while allowing adaptive generalization relevant to archipelagic defense governance.

3. Results and Discussion

3.1 Strategic analysis of Eastern Indonesia's maritime defense

Eastern Indonesia's maritime defense posture presents a deep paradox: despite the region's exceptional geostrategic significance, it remains structurally and institutionally vulnerable due to development imbalances and critical infrastructure gaps. A comprehensive strategic analysis must consider three key dimensions: geographic and geostrategic characteristics, the spectrum of maritime threats, and the limited capacity of maritime defense industries.

Geographic and geostrategic characteristics, the vast maritime expanse of Eastern Indonesia includes provinces such as Sulawesi, Maluku, East Nusa Tenggara, and Papua, characterized by disproportionately large sea areas compared to land. Open waters like the Banda Sea, Arafura Sea, and the Pacific Ocean directly border foreign nations, making maritime surveillance and law enforcement logistically complex (Yang et al., 2025). Patrolling these vast zones demands significant fuel and logistical support. Moreover, thousands of small, often uninhabited islands scattered across the region serve as potential transit points or hideouts for illegal activities (Patel et al., 2022). The existence of ALKI II and ALKI III Indonesia's designated sea lanes for international navigation further amplifies the strategic importance and risk profile of the region (Floristella, 2012).

Spectrum of maritime security threats, the region faces a high concentration of both traditional and non-traditional maritime threats. Illegal, unreported, and unregulated (IUU) fishing is the most pressing, threatening national sovereignty and marine ecosystems, and often linked to modern slavery (Khan et al., 2024). According to Bakamla's 2023 report, these illegal practices result in billions of dollars in annual losses. Piracy and armed robbery, while less frequent than in the Malacca Strait, remain a threat in poorly monitored sea lanes. Eastern maritime borders also serve as key routes for smuggling narcotics, firearms, and human trafficking (Runturambi & Arifin, 2025). Territorial violations by foreign vessels, if mismanaged, may escalate into diplomatic crises. Additionally, the threat of maritime terrorism lingers due to extremist activities in surrounding areas (Auld et al., 2023). Environmental risks and maritime natural disasters like tsunamis further compound the region's vulnerability (Kismartini et al., 2024).

Infrastructure and defense industrial limitations, despite the diverse threat landscape, Eastern Indonesia's maritime defense infrastructure remains underdeveloped. Most local shipyards are small-scale and incapable of constructing or maintaining modern naval vessels, forcing TNI AL ships to seek maintenance in Java. There is also a severe shortage of skilled professionals engineers, technicians, and defense planners. The scarcity of advanced technology and high-risk investment climate further stifles industrial growth (Lin et al., 2025). Weak research and development capacity, combined with insufficient collaboration among universities, industries, and the Navy, inhibits innovation (Riillo, 2025). Moreover, fragmented inter-agency coordination continues to cause jurisdictional overlaps and enforcement blind spots (Amin et al., 2024). In summary, while Eastern Indonesia holds pivotal importance for Indonesia's maritime sovereignty, its defense posture remains critically underprepared. These gaps weaken Indonesia's broader strategic vision as the Global Maritime Fulcrum. A focused, multi-actor approach such as the Hexa-Helix collaboration model is necessary to address these multidimensional challenges.

To quantify the extent of this geographic imbalance, Table 2 presents a Geographic Concentration Index (GCI) derived from the TNI-AL infrastructure data in Table 1. The GCI measures the proportion of total assets in each infrastructure category located within each of Indonesia's three geographic zones: Western Indonesia (Java, Sumatra, Kalimantan, Bali-NTT), Central Indonesia (Sulawesi, Maluku, North Maluku), and Eastern Indonesia (Papua and West Papua). The index reveals that the average concentration of TNI-AL strategic assets in Western Indonesia stands at 77%, while Eastern Indonesia which borders the Pacific Ocean and is most proximate to several contested maritime zones, hosts only 16% of total naval infrastructure (TNI AL, 2024; Arifin et al., 2024).

The source of the data in the Table 2 is based on research analysis using official infrastructure data from the Indonesian Navy (TNI AL, 2024). The concentration levels are categorized as CRITICAL when 90–100% of the infrastructure is concentrated in Western Indonesia and HIGH when 50–89% is concentrated in the same region. Western Indonesia comprises Java, Sumatra, and Kalimantan, while Central Indonesia includes Sulawesi and Maluku, and Eastern Indonesia refers to Papua Province.

Four infrastructure categories record a CRITICAL concentration level, meaning that 90–100% of their assets are located exclusively in Western Indonesia: Special Infrastructure (Pushidrosal, Kolinlamil), Education and Training Institutions, Strategic Weaponry and Arsenal facilities, Specialist Health Services, and Command & Control Infrastructure. This means that a naval officer stationed in Eastern Indonesia who requires specialist medical care, advanced training, or technical maintenance must travel to Java a journey of thousands of kilometers. The operational and morale costs of such an arrangement are significant, contributing to chronically lower readiness levels in eastern commands compared to their western counterparts (Amin et al., 2024).

Table 2. Geographic concentration index (GCI) of Indonesian Navy strategic assets by region

Infrastructure Category	Western Indonesia	Central Indonesia	Eastern Indonesia	Concentration Level
Fleet Commands	67%	0%	33%	High
Main Naval Bases (Lantamal)	50%	21%	29%	High
Naval Air Bases	50%	25%	25%	High
Maintenance & Logistics	50%	25%	25%	High
Special Infrastructure (Pushidrosal, Kolinlamil)	100%	0%	0%	Critical
Education & Training Institutions	100%	0%	0%	Critical
Special Forces Commands	67%	0%	33%	High
Strategic Weapony / Arsenal	100%	0%	0%	Critical
Specialist Health Services	100%	0%	0%	Critical
Command & Control Infrastructure	90%	0%	10%	Critical
Overall Average	77%	7%	16%	High

(TNI AL, 2024)

The GCI data also reveal an important pattern in the distribution of special forces. While Pasmar 3 and a Kopaska unit are based in Sorong (Eastern Indonesia), these represent only the forward-deployed components of larger formations headquartered in Jakarta and Surabaya. The strategic reserve, training, logistics, and command functions remain centralized in the west. This means that in the event of a rapidly escalating hybrid threat in the Sulu Sea or the Banda Sea, initial response would need to be sustained by forces that are structurally dependent on logistics chains stretching back to western Indonesia a significant operational vulnerability that adversaries aware of TNI-AL's structure could potentially exploit (Rustam et al., 2022; Chapsos & Malcolm, 2017).

3.2 The complexity of threats in sulu waters and the need for an integrated approach

The Sulu Sea, located between the southern Philippines, eastern Malaysia (Sabah), and Eastern Indonesia (North Sulawesi and Maluku), has become one of the highest-risk maritime zones in the region. For decades, this area has been identified as a hotspot for cross-border crimes due to its complex maritime topography and weak surveillance capacity among the bordering nations. One of the main destabilizing actors is the Abu Sayyaf Group (ASG), known for repeated involvement in kidnappings, extortion, and arms smuggling. These operations not only generate fear among coastal communities and fishers but also disrupt vital regional maritime trade routes (Sevgili et al., 2025).

In addition to security threats posed by militant groups, the Sulu Sea has also become a locus of persistent and systematic Illegal, Unreported, and Unregulated (IUU) fishing. These activities not only inflict severe economic losses reaching billions of dollars annually but also erode state sovereignty over marine resources (Kadfak & Linke, 2021). Indonesia's eastern frontier, particularly around the Sulu waters, faces serious limitations in detection systems and maritime surveillance. Weak radar infrastructure, lack of patrol vessels, and under-resourced outposts with few trained personnel severely hinder enforcement over Indonesia's Exclusive Economic Zone (Bethel, 2025).

The nature of these threats is hybrid and unconventional. Rather than manifesting as open military aggression, they take the form of transnational crimes embedded in the socioeconomic fabric of coastal communities. Conventional military responses centered on deterrence and the deployment of assets are insufficient to create long-term stability. Hard-power-focused security strategies tend to be ill-suited to address agile, decentralized threats often carried out by non-state actors integrated within local populations.

What is urgently needed is a multidimensional, integrated approach that combines defense capabilities with civil engagement, institutional capacity building, and advanced maritime technologies. Community-based maritime security allows coastal residents to participate in early detection systems, suspicious activity reporting, and real-time tactical information dissemination. Technologies such as unmanned surface vehicles (USVs), AI-powered radar, and satellite monitoring can fill persistent gaps in border surveillance (Chapsos & Malcolm, 2017). Similar models have been effectively implemented in other island nations such as the Philippines and Sri Lanka.

Given that the threats in the Sulu Sea are not isolated but intertwined with regional instability and international criminal networks, adopting a preventive, actor-inclusive, and collaborative response is critical. Indonesia must shift from reactive enforcement to anticipatory strategies through systemic integration. The Hexa-Helix collaboration model offers a strategic blueprint by uniting government, military, academia, industry, society, and media into one synergistic maritime defense framework. Without an integrated and adaptive approach responsive to evolving threats, the Sulu Sea will remain locked in a cycle of insecurity that undermines national maritime sovereignty and regional stability.

3.3 Theoretical basis of hexa-helix

The conceptual foundation of the Hexa-Helix model is deeply rooted in the evolution of multi-actor innovation collaboration theory, starting from the Triple Helix and expanding through the Quadruple and Quintuple Helix models. Each additional helix represents the formal recognition of emerging stakeholders in innovation ecosystems. The original Triple Helix comprising government, industry, and academia was later expanded to include civil society (Quadruple Helix) and the environment or media (Quintuple Helix), reflecting the growing importance of public engagement and sustainability in innovation processes (Wei et al., 2025; Carayannis & Preissler, 2025; Durán-Romero et al., 2020).

In the context of maritime defense development in Eastern Indonesia, the Hexa-Helix model becomes particularly relevant by explicitly adding the Navy and media as separate helices. The Navy, distinct from the general role of government, is the primary end-user of defense technology and plays a strategic role in applied R&D, testing, and procurement

(Bagus & Hanaoka, 2022). The media, meanwhile, is critical in shaping public discourse, enhancing maritime literacy, and ensuring public accountability in defense projects (Riemann, 2025). Their inclusion reflects the complex and hybrid nature of maritime security challenges and the need for transparent, community-supported, and technologically informed responses.

Each helix plays a complementary role: the government provides strategic regulation and infrastructure (Humang, 2025); the Navy defines operational needs and facilitates testing; academia develops innovations and talent pipelines (Haridison, 2024); industry manufactures and commercializes technologies; civil society legitimizes and supports initiatives (Arifin et al., 2024); and media facilitates communication, oversight, and stakeholder engagement. Their synergy forms an adaptive and resilient ecosystem capable of addressing regional disparities in maritime defense and transforming Eastern Indonesia into a hub of autonomous defense innovation. Building on the theoretical foundations of the Hexa-Helix model, Table 3 presents an empirical assessment of the current engagement level, comparative strengths, key limitations, and integration gaps of each of the six helix actors within Indonesia's existing maritime defense governance architecture.

Table 3. Hexa-helix actor engagement assessment: Indonesia's maritime defense governance

Helix Actor	Engagement Level	Key Strengths	Key Limitations	Integration Gap
Government	High	Regulatory authority; diplomatic standing; fiscal control	Inter-ministry fragmentation; political cycle constraints; centralization bias	Low-Medium
Navy (TNI AL)	High	Coercive capacity; force projection; operational intelligence	Geographic asset concentration; institutional insularity; hybrid-threat threshold constraints	Medium
Academia	Low-Medium	Analytical capability; technological R&D; human capital development	Slow knowledge cycle; limited security clearance; weak policy-research linkage	High
Industry	Low	Commercial maritime intelligence; shipbuilding assets; satellite data	Competing commercial interests; proprietary data concerns; limited eastern presence	Very High
Civil Society	Very Low	Place-based knowledge; social trust; community surveillance networks	Organizational capacity variability; vulnerability to coercion; no secure reporting channel.	Very High
Media	Low	Public accountability; maritime literacy promotion; counter-disinformation	Credibility variability; limited defense knowledge; potential for external manipulation	High

(TNI AL, 2024)

Table 3 reveals a stark bifurcation in helix engagement. The Government and Navy helices operate at a high engagement level, but with significant internal limitations, principally the inter-ministry fragmentation on the government side and the geographic concentration problem on the navy side. The remaining four helices Academia, Industry, Civil Society, and Media, are characterized by low to very low engagement and high to very high integration gaps, meaning that their considerable potential contributions to maritime defense governance are largely unrealized under current institutional arrangements. This pattern is consistent with Castellacci & Natera's (2013) observation that innovation ecosystems in developing contexts often exhibit "partial helix activation" where the state-military dyad dominates while non-governmental actors remain systematically marginalized, reducing overall system resilience and adaptive capacity.

The very high integration gaps identified for Civil Society and Industry helices are particularly consequential given the hybrid nature of the threats Indonesia faces. Hybrid maritime threats specifically target the civilian-military boundary, exploiting the inability of purely military governance systems to monitor and respond to threats embedded within commercial and community contexts (Carayannis & Preissler, 2025, 2012; Ellett et al., 2025). Without formal integration of commercial maritime intelligence available through shipping companies, port operators, and satellite imagery providers and community-based surveillance networks, Indonesia's maritime domain awareness will remain characterized by systematic blind spots in exactly the areas where hybrid threats are most active.

3.4 The strategic position of the hexa-helix model in the maritime defense system

The Hexa-Helix model offers a strategic and adaptive framework for designing a collaborative maritime defense system capable of responding to multidimensional threats. It brings together six key actors government, Navy, academia, industry, civil society, and media into a dynamic and complementary ecosystem. In the context of increasing maritime security complexity, especially in border zones such as the Sulu Sea, the model helps overcome institutional fragmentation and capacity disparities by promoting a whole-of-government and whole-of-society approach (Chen et al., 2024).

Each helix plays a critical role. The government, both central and local, not only formulates defense policy but also provides regulatory and fiscal frameworks that enable synergies across stakeholders. Through ministries such as Defense and Industry, the government can offer tax incentives, accelerate permits, and develop maritime industrial infrastructure, while local governments integrate defense with regional economic agendas (Jannah et al., 2025).

The Navy serves as an operational actor and a knowledge hub, offering input on technical requirements and battlefield experience to guide defense capability development. Collaboration with domestic industries like PT PAL and PT Dahana, and decentralization of logistics and maintenance facilities to Eastern ports like Ambon and Bitung, would increase readiness and reduce Java-dependence (Jannah et al., 2025).

Academic institutions contribute applied research and capacity building through R&D in AI-based surveillance, acoustic sonar systems, and satellite imaging. These innovations, along with skills training, can accelerate local defense industry growth. Examples from South Korea and Turkey show how academia-military-industry partnerships drive national defense innovation (Byrne et al., 2025).

Civil society, particularly coastal communities, plays a key role in community-based maritime surveillance and early warning. Empowering these actors through training, communication tools, and GIS-integrated systems enhances national awareness and counters criminal infiltration (Pitakaso et al., 2024). Media completes the ecosystem by informing public opinion, promoting defense literacy, and holding institutions accountable. Its role is especially critical in contested border zones like Sulu, where it can counter misinformation campaigns and external propaganda (Riemann, 2025).

3.5 Institutional and collaborative governance as instruments for maritime defense reform

Operationalizing the Hexa-Helix model in maritime defense requires fundamental institutional reform. One of the main barriers in Eastern Indonesia is the fragmented and vertically oriented nature of defense governance, which limits coordination among key stakeholders, especially between local governments, industries, academia, and civil society (Bethel, 2025). This siloed structure often leads to overlapping regulations, weak command-and-control interoperability, and inefficient infrastructure development misaligned with actual maritime threats.

To address this, a permanent and cross-sectoral body such as a Maritime Defense Innovation Council (MDIC) should be established in Eastern Indonesia. MDIC would function as a strategic coordination platform integrating all six Hexa-Helix actors government, Navy, academia, industry, civil society, and media into a joint cycle of planning, implementation, and evaluation. Additionally, MDIC can act as a maritime intelligence aggregator, academic-policy interface, and evidence-based defense policy incubator that tailors procurement and innovation to regional oceanographic and demographic realities (Lee & Kim, 2024).

For example, patrol vessel designs must vary based on local maritime conditions deep waters like the Maluku Sea require different specifications than shallow waters like the Madura Strait. Such differentiated needs can be addressed through triple-loop learning collaborations among the Navy, defense R&D institutes, and local maritime engineering faculties (Hui & Geng, 2024).

Institutional reform must also include fiscal policy restructuring to decentralize defense investment. Currently, defense industries are concentrated in western Indonesia due to limited incentives in remote eastern regions. To counter this, progressive incentives such as import duty exemptions, tax holidays for shipyards, and the development of defense-oriented Special Economic Zones (SEZs) in Ambon, Bitung, or Tual are needed (Kusuma-Atmadja & Purwaka, 1996).

A critical dimension of institutional reform under the Hexa-Helix model is the formal integration of maritime intelligence flows across all six helices. Currently, maritime intelligence in Indonesia follows a predominantly vertical and classified chain, flowing upward through Indonesian Navy command structures with limited lateral sharing across agencies, sectors, or governance levels. This architecture is fundamentally misaligned with the distributed, multi-domain nature of hybrid threats, which generate intelligence signals across civilian, commercial, and digital domains that military intelligence channels are ill-equipped to capture (Chen et al., 2024; Kismartini et al., 2024). A Maritime Intelligence Fusion Center (MIFC), as envisioned under the Hexa-Helix framework, would institutionalize lateral intelligence sharing by aggregating inputs from naval surveillance systems, commercial AIS platforms, satellite imagery providers, academic threat assessments, community monitoring networks, and media-derived open-source intelligence into a unified maritime domain picture. The MIFC model has been successfully piloted by regional partners including Singapore's Information Fusion Centre and Australia's Maritime Border Command, offering transferable institutional lessons for Indonesian adaptation (Chapsos & Malcolm, 2017; Cannon, 2025).

The role of the Media helix in the Hexa-Helix model deserves particular elaboration, as it represents the most theoretically novel element of the proposed framework. Beyond its conventional function as a vehicle for public information, the Media helix in maritime defense governance performs three distinct strategic functions. First, it serves as a counter-disinformation platform, capable of challenging false narratives propagated by hostile actors regarding Indonesia's maritime sovereignty claims and naval capabilities a function of growing importance in the information-warfare dimension of hybrid threats (Riemann, 2025). Second, it functions as a maritime literacy multiplier, building public understanding of and support for the investment requirements of maritime defense a critical enabler for the sustained political commitment that infrastructure equalization programs require. Third, it acts as a public accountability mechanism, providing civilian oversight of defense

programs and ensuring that governance reforms under the Hexa-Helix model remain transparent and resistant to institutional capture. These three functions collectively make the Media helix not a peripheral element but a structural necessity for the long-term sustainability of the governance architecture (Rochwulaningsih et al., 2019; Riemann, 2025).

The proposed Maritime Defense Innovation Council (MDIC), as the institutional anchor for Hexa-Helix operationalization, should be designed with three core structural features that distinguish it from existing inter-agency coordination bodies. First, it must possess a genuine cross-sectoral mandate authority the legal capacity to require information sharing and collaborative action across ministries, military branches, and civilian sectors, rather than merely functioning as a consultative forum whose recommendations are advisory. Second, it must be permanently resourced with a dedicated secretariat and analytical capacity, rather than relying on seconded personnel from member agencies whose primary loyalties and workloads remain with their home institutions. Third, it must include binding performance accountability mechanisms, regular public reporting on maritime governance outcomes, helix engagement metrics, and infrastructure equalization progress that create institutional incentives for sustained participation and deter the bureaucratic free-riding that has historically undermined inter-agency coordination in Indonesian maritime governance (Dirhamsyah et al., 2022; Haridison, 2024; Bethel, 2025).

Beyond fiscal tools, the model must embrace open innovation principles to connect defense ecosystems with local tech actors startups, research incubators, and maker-spaces. This has succeeded in countries like South Korea and Israel, where startups lead in developing ocean sensors, tactical navigation, and autonomous maritime systems. Through MDIC, Hexa-Helix becomes not only a collaborative model but also a national innovation platform adaptive to evolving threats and maritime geopolitical shifts. In short, without transformative governance, the Hexa-Helix model risks remaining a normative concept. Institutional innovation and fiscal restructuring are prerequisites for making it a viable and sustainable solution for maritime defense reform in Eastern Indonesia (Bethel, 2025; Lee & Kim, 2024; Hui & Geng, 2024; Kusuma-Atmadja & Purwaka, 1996).

3.6 Potential impact and strategic relevance of the hexa-helix model in Eastern Indonesia

The successful implementation of the Hexa-Helix model in the Sulu Sea region holds transformative potential both locally and strategically within the broader Indo-Pacific geopolitical context. As part of vital sea lanes like ALKI II and ALKI III, Eastern Indonesia occupies a crucial position in global maritime networks (Cannon, 2025). The model enhances comprehensive maritime security by enabling collaboration among six key stakeholders: government, Navy, academia, industry, civil society, and media, to address threats such as piracy, terrorist infiltration, and illegal maritime exploitation.

Strategically, the Hexa-Helix framework can serve as a national benchmark for adaptive and participatory defense systems. It promotes synergy across sectors previously siloed, integrating hard (military) and soft (social and technological) components of security (Ellett et al., 2025). In the regional context, it reinforces Indonesia's position in cooperative frameworks such as the Trilateral Cooperative Arrangement (TCA) with the Philippines and Malaysia, by boosting interoperability and civil society engagement (Cannon, 2025).

The model also supports defense industrial decentralization, reducing Java-centric dependency by promoting growth in areas like Ambon and Bitung, thus improving operational response time. Socially, integrating coastal communities into community-based maritime surveillance systems fosters social resilience and ownership, reducing marginalization and vulnerability to radicalization (Rustam et al., 2022).

Policy-wise, the Hexa-Helix facilitates institutional coherence between defense planning, local development, and innovation agendas. If consistently supported by institutional reforms and strategic investment, it can evolve into a resilient and inclusive maritime defense ecosystem capable of responding to the dynamic challenges of the Indo-Pacific (Cannon, 2025; Ellett et al., 2025)

3.7 Mitigation strategies and challenges

Implementing the Hexa-Helix model in Eastern Indonesia's maritime defense ecosystem faces a range of structural, technical, and social challenges that require tailored and coordinated mitigation strategies. First, regulatory harmonization is essential to overcome overlapping policies and fragmented coordination. The establishment of a National Maritime Coordination Committee and cross-sectoral maritime task forces can align central and regional actors effectively (Dirhamsyah et al., 2022). Second, the lack of collaborative culture and institutional resistance can be addressed by promoting strategic literacy through joint training and personnel exchange programs. These initiatives help build trust and shared ownership among stakeholders (Haridison, 2024).Third, bridging the innovation gap in Eastern Indonesia requires decentralized technology platforms. The development of Maritime Innovation Hubs in cities like Ambon and Sorong can foster partnerships between academia, the Navy, and local industries to generate context-specific solutions (Lee & Kim, 2024). Fourth, social inclusion challenges must be met through community-based approaches. Expanding inclusive Community-Based Maritime Surveillance (CBMS) programs empowers coastal communities as active partners in maritime monitoring and deterrence (Bagus & Hanaoka, 2022). To ensure sustainability, these four strategies must be guided by a long-term roadmap overseen by a permanent institution like the Maritime Defense Innovation Council. Without systemic mitigation, the Hexa-Helix model risks remaining a conceptual ideal rather than a practical force for transforming Indonesia’s maritime defense (Dirhamsyah et al., 2022; Haridison, 2024; Lee & Kim, 2024; Bagus & Hanaoka, 2022).

4. Conclusions

Eastern Indonesia’s maritime frontier illustrates a paradox: despite its high geostrategic value, it remains institutionally and infrastructurally fragile in the face of hybrid maritime threats. This study concludes that existing sectoral approaches centered predominantly on military responses are insufficient to address the complex and transboundary risks that dominate critical zones such as the Sulu Sea. As a solution, this research introduces the Hexa-Helix collaboration model as a novel strategic governance framework that redefines stakeholder integration by institutionalizing six autonomous actors: government, Navy, academia, industry, civil society, and media. The inclusion of the Navy and media as independent helices marks a theoretical advancement from the traditional Triple and Quintuple Helix models, aligning national defense needs with knowledge production, innovation systems, and communicative governance.

The core contribution of this study lies in bridging the gap between innovation theory and national defense strategy in an archipelagic, hybrid-threat context. The Hexa-Helix model offers not only a conceptual refinement but also an adaptive framework applicable to real-world maritime governance challenges in Eastern Indonesia. By fostering multilevel coordination, stimulating localized defense industry development, and enhancing public maritime awareness, this model supports the emergence of a sustainable, participatory, and sovereign defense ecosystem. The proposed framework thus contributes to the advancement of collaborative governance theory, strategic defense studies, and maritime security policy, with broader implications for archipelagic states facing similar security asymmetries in the Indo-Pacific region.

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