

Transformation Caused by Marine Sediment Mining in Karimun Besar Island: A Documentary Analysis and Its Implications for Non-Traditional Maritime Security

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Abstract

Marine sediment mining in the Riau Islands Province, particularly around Karimun Besar Island, has created a multidimensional challenge involving ecological degradation, socio-economic disparities, and maritime security concerns. This study aims to analyze the ecological transformation and its implications for non-traditional maritime security using a qualitative documentary analysis approach. Data were obtained from six scientific journals and institutional reports from BMKG, KLHK, and IOJI. The results reveal that intensive sand extraction has caused significant geomorphological changes, including seabed deformation, shoreline erosion, and mangrove degradation of up to 40% between 2015 and 2023. Although mining activities have increased local household income by approximately 20%, labor absorption remains minimal at only 4%, leading to social inequality and community tension. Furthermore, environmental damage has weakened coastal resilience and triggered non-traditional security threats such as cross-border fishing, smuggling, and local conflicts. The study concludes that marine sediment mining in Karimun Besar represents a paradox of development economic gains coexist with ecological and security degradation. To address this issue, Indonesia must adopt an eco-maritime security governance model that integrates environmental protection, socio-economic sustainability, and inter-agency maritime coordination to maintain national resilience and Good Order at Sea.



Keywords: Marine Sediment Mining, Coastal Ecosystem, Non-Traditional Maritime Security, Geomorphological Change, Eco-Maritime Governance

INTRODUCTION

The issue of marine sediment mining in Indonesia, especially in the Riau Islands Province, has become a complex problem that involves environmental, economic, and security aspects (Sofiyani et al., 2012). Since the late 1990s, the strategic location of this region near the Malacca Strait has attracted large-scale sand extraction activities, mainly for reclamation projects in neighboring countries (Faradilla et al., 2024). These operations, which often lacked strict environmental supervision, have caused severe damage to the seabed and changed the coastal morphology of Karimun Besar Island. Continuous dredging has led to coastal erosion, declining water quality, and the destruction of mangrove and seagrass ecosystems that function as natural barriers against tidal waves (Lestari et al., 2023). This ecological damage has also affected the livelihoods of local fishermen who depend on the coastal ecosystem as their main source of income.

To respond to these issues, the Indonesian Government issued Government Regulation (PP) No. 26 of 2023 on the Management of Marine Sediments (Government of Indonesia, 2023). The regulation aims to regulate the utilization of seabed materials for reclamation, infrastructure, and environmental restoration. However, its implementation remains controversial because many environmental observers and local communities worry that this regulation might reopen large-scale dredging practices previously banned in 2003 due to their negative ecological impacts (KLHK, 2023). In addition, the lack of coordination among institutions, overlapping authority between maritime enforcement agencies, and weak supervision make it difficult to ensure effective environmental protection. As a result, the Riau Islands—particularly Karimun Besar—are now facing a dilemma between economic development and environmental sustainability.

Environmental degradation from sediment mining is not only an ecological issue but also closely related to non-traditional maritime security (Rahmad, 2024). Damaged ecosystems increase social vulnerability and can trigger illegal fishing, smuggling, and even small-scale resource conflicts between communities (Fauzy et al., 2025). In this context, the concept of Non-Traditional Security (NTS) expands the meaning of security beyond military threats, including environmental and socio-economic factors that affect national stability (Buzan, Wæver, & de Wilde, 1998). The weakening of coastal ecosystems in border areas like Karimun Besar can reduce maritime domain awareness and threaten Indonesia's sovereignty in the Malacca Strait (Bueger,



2015).

Based on these conditions, this research aims to analyze how marine sediment mining activities influence the stability of coastal ecosystems and non-traditional maritime security. Through a qualitative documentary analysis approach, this study examines the relationship between ecological changes, community adaptation, and maritime governance within Indonesia's sustainable maritime policy framework (Miles & Huberman, 2014). The results are expected to provide insights for developing an eco-maritime security management model that integrates environmental protection, social welfare, and maritime stability in line with Indonesia's vision as a Global Maritime Fulcrum (IOJI, 2024; Till, 2009).

OVERVIEW OF CONNECTIVISM

Connectivism is a contemporary learning theory that emphasizes the role of networks, information flow, and interconnectivity among individuals, systems, and technologies in shaping knowledge acquisition (Siemens, 2005). Unlike traditional learning theories such as behaviorism or constructivism, connectivism recognizes that learning occurs not only within human cognition but also across digital and institutional networks that store and transfer information dynamically. In the context of maritime governance, this theory provides a useful framework for understanding how environmental knowledge, legal frameworks, and security practices are interconnected within a broader socio-technical system.

According to Downes (2012), connectivism suggests that knowledge resides in networks, and the ability to navigate, link, and evaluate these networks determines an actor's learning capacity. This is particularly relevant to maritime security institutions—such as BAKAMLA, KPLP, and POLAIRUD—which must integrate multisectoral data and coordinate through shared maritime domain awareness (MDA) systems. The effectiveness of such collaboration depends on the ability of each institution to connect environmental monitoring data, community-based reports, and policy information through digital platforms and interagency communication networks.

In the case of marine sediment mining in Karimun Besar, the connectivist framework can explain how fragmented information systems contribute to weak enforcement and limited ecological oversight. Environmental data collected by the Ministry of Environment (KLHK), hydrological data from BMKG, and legal documents from IOJI often exist in separate silos, reducing the overall situational awareness required for sustainable decision-making. A connectivist approach encourages the establishment of an integrated *eco-maritime data network* that allows



for real-time information exchange among institutions, thereby enhancing both ecological governance and maritime security resilience.

Furthermore, connectivism underscores the importance of community participation in data generation and knowledge sharing. Local fishers and coastal communities, as knowledge holders, can contribute to early warning systems and environmental reporting through digital connectivity tools. By incorporating community-based environmental intelligence into formal monitoring systems, Indonesia can strengthen its *eco-maritime security governance* model and ensure that knowledge flows are not limited to top-down institutional mechanisms but also inclusive of grassroots participation.

Overall, the connectivism perspective reinforces the idea that effective maritime governance in the era of digital transformation requires an interconnected learning ecosystem among state agencies, academia, civil society, and local communities. In this sense, managing marine sediment mining and its socio-ecological consequences demands not only regulatory alignment but also a collective learning network that bridges the gap between environmental science, maritime policy, and social resilience.

OVERVIEW OF CONSTRUCTIVISM

Constructivism is a theory of knowledge and learning that emphasizes how individuals and institutions actively construct meaning based on their experiences, interactions, and interpretations of the surrounding environment (Piaget, 1972; Vygotsky, 1978). Unlike positivist or behaviorist paradigms that assume knowledge as an objective reality to be transmitted, constructivism argues that knowledge is socially constructed through human engagement, contextual understanding, and continuous reflection. This theoretical approach provides an essential lens for analyzing maritime governance, particularly in explaining how environmental, social, and security actors interpret and respond to complex issues such as marine sediment mining in Karimun Besar.

In the constructivist view, the actions of maritime stakeholders—government institutions, local communities, and environmental organizations—are not merely determined by material factors but are shaped by shared norms, values, and perceptions about the meaning of “security” and “sustainability” (Wendt, 1992). For instance, when coastal degradation occurs due to sediment mining, responses from different institutions often vary depending on how each actor defines maritime security—whether as protection of sovereignty, ecological integrity, or social welfare. This highlights that maritime security governance is not only a matter of power and



regulation but also a product of constructed social realities.

Constructivism also helps explain the formation of interagency coordination and policy coherence within Indonesia's maritime governance system. The lack of synergy among BAKAMLA, KPLP, and POLAIRUD, as noted in previous analyses (IOJI, 2024), can be understood as a consequence of differing institutional identities and epistemic cultures. Each agency constructs its own understanding of "security" and "maritime responsibility," leading to fragmented practices and limited integration of environmental concerns. Through a constructivist framework, strengthening eco-maritime governance thus requires reshaping institutional norms and shared understandings, not merely reforming laws or issuing new regulations.

From a socio-environmental perspective, constructivism provides a foundation for understanding community adaptation and collective resilience. Local communities in Karimun Besar construct their own environmental knowledge based on daily experiences with changing coastal dynamics, sediment shifts, and declining fisheries. Their lived experiences contribute to an alternative form of local ecological knowledge (LEK) that, when recognized by policymakers, can enhance participatory governance and improve non-traditional maritime security outcomes. Therefore, the constructivist paradigm supports a bottom-up approach to policy formulation—emphasizing dialogue, shared meaning, and the co-construction of solutions between the state and society.

In conclusion, constructivism enriches the study of maritime security and environmental governance by framing knowledge as a dynamic, context-dependent process. It explains how perceptions, discourses, and institutional identities shape responses to environmental degradation, and it underscores the need for shared understanding among stakeholders to achieve integrated, sustainable maritime governance. Applying constructivist principles in Indonesia's maritime domain can help bridge the gap between policy and practice, ensuring that environmental protection and national security are grounded in common socio-cultural values.

SOCIAL LEARNING THEORY

Social Learning Theory, developed by Albert Bandura (1977), emphasizes that learning occurs through observation, imitation, and interaction within a social context. It bridges behavioral and cognitive theories by explaining how individuals and groups acquire new knowledge, values, and behaviors through social engagement, role modeling, and reinforcement. In environmental and maritime governance, social learning is essential in understanding how communities and institutions adapt their behavior to respond to ecological changes and



governance challenges.

In the context of marine sediment mining in Karimun Besar, social learning can be observed in how local communities, government institutions, and maritime enforcement agencies influence one another in constructing adaptive responses to environmental degradation. Coastal communities, for instance, learn sustainable practices through shared experiences, collective discussions, and observation of the consequences of over-exploitation. Similarly, institutions such as BAKAMLA, KPLP, and POLAIRUD enhance their operational coordination through cross-agency collaboration and knowledge exchange—reflecting a process of *organizational learning* built on social interaction and mutual observation (Pahl-Wostl, 2009).

Social learning also highlights the role of communication and trust in building effective eco-maritime governance. When local stakeholders participate in decision-making, knowledge transfer occurs not merely through formal training but also via informal interactions, local narratives, and participatory monitoring activities. This participatory form of learning strengthens collective responsibility, fosters environmental stewardship, and enhances *maritime domain awareness* (MDA) at the community level (Reed et al., 2010).

Furthermore, Social Learning Theory provides a foundation for integrating scientific knowledge with local ecological wisdom (LEK). The process of co-learning between government agencies, researchers, and local communities contributes to policy legitimacy and ensures that governance frameworks reflect real environmental and social conditions. In this sense, social learning becomes not only a mechanism of behavioral adaptation but also a strategy for improving the resilience of maritime governance systems against non-traditional security threats.

Overall, applying Social Learning Theory to the governance of marine sediment mining emphasizes that achieving sustainable maritime security is not solely dependent on regulations or institutional mandates but also on continuous social interaction, shared experiences, and mutual adaptation. This theory supports the development of *eco-maritime security governance* where learning processes among actors—state, community, and civil society—lead to more inclusive, adaptive, and resilient maritime management.

THEORETICAL INSIGHT

A rich and multidisciplinary theoretical foundation underpins the development of *Social Learning Theory* and its relevance to adaptive governance in dynamic environments such as maritime security. According to Biele et al. (2009), Rendell et al. (2010), and Whitehead and Richerson (2009), social learning involves active negotiation between individual cognition and



collective imitation, raising critical questions about compliance, contextual reliability, and the potential transmission of misinformation. These studies highlight that social learning can enhance cooperation and information diffusion, but it also carries risks when imitation occurs without critical evaluation.

Rogers' (1988) paradox provides an essential starting point for understanding the evolutionary logic of social learning. In his numerical model, Rogers demonstrated that social learning does not inherently improve the overall well-being of a population because its effectiveness is *frequency-dependent*. Social learners rely on asocial learners to generate new knowledge but can reduce their own learning costs by imitating others. However, when imitation becomes too widespread, it leads to redundancy and the propagation of outdated or false information. This paradox underscores that a balanced interaction between innovation (asocial learning) and imitation (social learning) is crucial for adaptive governance—an idea highly relevant to maritime institutional learning, where data sharing, duplication of policies, and institutional mimicry often shape interagency collaboration.

Building on this, Diefendorff and Lord (2008) differentiate between *systemic* and *content* theories of self-regulation, emphasizing that social learning functions as part of a broader self-regulatory system. Systemic theories—such as Social Learning and Control Theory—focus on feedback loops, goals, and corrective adjustments within human and institutional behavior (Carver & Scheier, 1998). Meanwhile, content theories like Goal Alignment Theory (Dweck, 1986) explore how perceptions, motivation, and value orientation shape adaptive decision-making. Within maritime governance, these frameworks imply that institutional alignment, shared objectives, and reinforcement of environmental values are necessary for cohesive eco-maritime management. The integration of structural (systemic) and content (goal-based) approaches enables a comprehensive understanding of how agencies regulate their strategies, align mandates, and learn collectively through reinforcement mechanisms.

Rebillion (2006) further emphasizes that reinforcement—the core mechanism of Social Learning Theory—should not only be seen as a reaction to stimuli but as a relational process linking cognition, social context, and behavior. In maritime policy enforcement, this can be understood through how peer institutions and officers learn from both sanctions and incentives, leading to behavioral adaptation over time. Such reinforcement dynamics are visible in interagency cooperation, where repeated coordination and shared operational experiences gradually internalize norms of compliance and ecological awareness.

Despite the vast understanding of the adaptive effects of social learning, the cognitive



systems underlying it remain less explored. Heyes (2012) argues that social and cognitive learning are often treated as distinct domains, even though imitation—a key component of social learning—is deeply rooted in cognitive processes. He posits that mechanisms enabling imitation and observational learning are not unique to social contexts but are extensions of general cognitive architecture. This insight bridges cognitive psychology and environmental governance by highlighting that sustainable maritime behavior—such as ecological compliance and collaborative monitoring—relies on both cognitive understanding and social reinforcement. In sum, *Theoretical Insight* from social learning research reveals that adaptive and sustainable maritime governance requires a balance between individual innovation, institutional imitation, and collective cognition. The integration of systemic self-regulation, goal alignment, and reinforcement principles can strengthen Indonesia's *eco-maritime security governance*, ensuring that policy learning is both reflective and responsive to ecological and social realities in regions like Karimun Besar.

CULTURAL EVOLUTION AND PRIMARY EDUCATION

Cultural evolution refers to the process through which human knowledge, behaviors, values, and social norms are transmitted and transformed across generations through learning and imitation (Boyd & Richerson, 1985). Unlike biological evolution, which operates through genetic inheritance, cultural evolution progresses through social learning, communication, and collective adaptation. In this view, learning becomes the mechanism that enables societies to accumulate knowledge, innovate, and respond to environmental challenges. The theory posits that cultural traits evolve through variation, selection, and retention—where adaptive ideas and practices that benefit social groups are maintained and disseminated (Mesoudi, 2011).

In the context of environmental governance and maritime education, the framework of cultural evolution provides a critical understanding of how ecological awareness and sustainable practices can be cultivated from an early age. Primary education serves as the foundational stage for transmitting pro-environmental values and maritime ethics that shape collective identity and behavior. As Henrich (2016) argues, cultural evolution operates through “cumulative cultural learning,” where children internalize not only cognitive knowledge but also social and moral norms that influence future decision-making. By embedding maritime and ecological literacy in early education, societies can create cultural pathways that reinforce environmental stewardship and collective responsibility.

Within Indonesia's maritime context, particularly in regions like Karimun Besar, cultural



evolution through education can help bridge traditional ecological knowledge (TEK) and modern scientific understanding. Many coastal communities possess inherited wisdom regarding tides, mangrove ecosystems, and fishing cycles. Integrating this local knowledge into primary school curricula fosters a culturally grounded sense of environmental identity, ensuring that future generations understand both the ecological and social dimensions of maritime security (IOJI, 2024). Through such integrative education, social learning becomes a medium for transmitting cultural adaptations essential to maintaining ecological resilience and sustainable livelihoods.

Moreover, cultural evolution theory suggests that educational systems act as cultural selection mechanisms. Practices and beliefs that are repeatedly reinforced through institutions—such as respect for marine biodiversity, collective resource management, and maritime ethics—are more likely to persist across generations (Laland, 2017). Therefore, schools play a vital role in reproducing adaptive cultural traits that sustain maritime stability. This is especially relevant to non-traditional maritime security, where environmental degradation and socio-economic inequality can be mitigated through a culturally rooted understanding of interdependence between humans and the sea.

In sum, the linkage between cultural evolution and primary education underscores that sustainable maritime governance begins with early cultural formation. Education not only transfers knowledge but also shapes values, behaviors, and worldviews that determine how societies relate to their marine environment. By integrating cultural evolution theory into maritime education policies, Indonesia can cultivate generations equipped with ecological intelligence, social resilience, and a deep commitment to safeguarding national maritime identity.

HIGHER EDUCATION SHIFT

The transformation of higher education in the 21st century reflects a paradigm shift from knowledge transmission toward knowledge co-creation and interdisciplinary problem-solving. This shift aligns with constructivist and social learning perspectives, which emphasize that knowledge is not passively received but actively constructed through social interaction, critical reflection, and collaborative inquiry (Vygotsky, 1978; Bandura, 1977). In the context of maritime studies, this transformation redefines the role of universities from traditional teaching institutions into dynamic centers of environmental adaptation, innovation, and governance learning.

In Indonesia, particularly within maritime-focused programs such as *Universitas Pertahanan Republik Indonesia* (UNHAN RI), the higher education shift is crucial for addressing the multidimensional challenges of marine resource management and security. The integration of



ecological literacy, policy analysis, and technological competency reflects a movement toward *eco-maritime education*—a framework that equips graduates not only with technical skills but also with the capacity to manage socio-environmental complexities. This aligns with the constructivist notion that learning emerges through contextual problem engagement, where students construct knowledge by analyzing real-world maritime issues such as sediment mining, illegal fishing, and marine pollution (Piaget, 1972; Wendt, 1992).

The higher education shift also mirrors the broader process of *cultural evolution* in knowledge institutions, where the flow of ideas, research norms, and interdisciplinary practices evolves through social learning networks. As Laland (2017) argues, cultural systems—like universities—adapt to changing environments by selectively retaining the most effective modes of learning and collaboration. In this regard, maritime universities and research institutions act as cultural transmission hubs, propagating sustainable norms and values through curriculum design, research collaborations, and policy engagement with maritime enforcement agencies such as BAKAMLA, KPLP, and POLAIRUD.

Moreover, higher education institutions increasingly serve as agents of *policy learning* within the framework of *non-traditional maritime security*. Through interlinkages between academia, government, and local communities, universities can facilitate multi-actor dialogue, data integration, and innovation in ocean governance. This reflects the principles of *connectivism* (Siemens, 2005), where knowledge exists within networks, and learning depends on the ability to identify, connect, and evaluate these informational nodes. In maritime governance, connectivist learning enables institutions to bridge fragmented data systems—environmental, social, and legal—into coherent strategies for sustainable management and crisis prevention.

The ongoing shift in higher education thus moves beyond academic instruction to foster *adaptive governance capacity*. It transforms maritime education into a participatory ecosystem where knowledge production, cultural adaptation, and institutional cooperation converge. By embedding ecological ethics, resilience thinking, and collaborative governance models into higher education curricula, Indonesia can cultivate a generation of maritime professionals capable of addressing both traditional and non-traditional security challenges with integrative, data-driven, and culturally responsive approaches.



Table 1. super system in six major ways

1. From Analog-to- Digital In the maritime research ecosystem, data collection and governance have transitioned from analog systems—manual logbooks, printed maps, and on-site observations—to digital monitoring tools and satellite-based data systems. The study on Karimun Besar utilizes <i>remote sensing</i>, GIS mapping, and digital archives from KLHK and BMKG to analyze geomorphological changes. This digitization enhances the accuracy, accessibility, and transparency of environmental information, allowing for real-time monitoring of sediment mining impacts and supporting Maritime Domain Awareness (MDA).
2. From Tethered to Mobile Maritime security and research activities that were once limited to fixed offices or coastal stations are now supported by mobile technologies. Field researchers and enforcement units (BAKAMLA, POLAIRUD, KPLP) can access hydrological databases, send geotagged photos, and communicate via mobile satellite devices while operating in remote marine zones. This mobility enables faster decision-making and inter-agency coordination in monitoring illegal sediment mining and environmental degradation.
3. From Isolated to Connected The management of marine ecosystems and security governance has shifted from fragmented institutional approaches to interconnected digital networks. The integration of data-sharing platforms between BMKG, KLHK, and IOJI exemplifies the transition from isolated datasets to connected knowledge systems. This connectivity strengthens <i>eco-maritime security governance</i>, where collaborative databases and cloud-based information sharing improve joint responses to environmental and non-traditional security threats in border regions.
4. From Standard to Personal Maritime learning and governance now prioritize contextual and community-based approaches. Educational programs, such as maritime security modules at Universitas Pertahanan RI, are increasingly designed to address local environmental realities, such as Karimun Besar’s geomorphological and socio-economic challenges. Personalization also appears in participatory monitoring where local fishermen use mobile apps to report coastal changes—making environmental management adaptive and human-centered.
5. From Consumers to Creators Previously, coastal communities were passive recipients of information regarding environmental management. Today, they are active creators of environmental data and local



narratives through citizen science, community mapping, and digital storytelling. Social media, open-access reporting tools, and low-cost data platforms allow communities to document ecological degradation, advocate for sustainable policies, and contribute directly to eco-maritime governance. This reflects the democratization of knowledge production in maritime policy.

6. From Closed to Open

The current era of *open data* and *open governance* has transformed maritime research and policy. Open-access platforms like IOJI's *Marine Governance Reports* and publicly shared datasets from BMKG and KLHK facilitate transparency, inter-agency collaboration, and public participation. Open-source analytical tools (e.g., QGIS, R, Python) are replacing expensive proprietary systems, allowing researchers and students to conduct advanced analyses on coastal changes at minimal cost. This openness fosters inclusivity, innovation, and collective responsibility in managing Indonesia's maritime resources.

SOCIAL LEARNING THEORY - ACADEMIC PERSPECTIVE

Social Learning Theory, originally developed by Albert Bandura (1977), provides a comprehensive explanation of how individuals and institutions acquire new behaviors, values, and knowledge through observation, imitation, and interaction within a social context. Bridging behavioral and cognitive traditions, this theory posits that learning does not occur solely through direct experience but also through the observation of others' actions and the perceived consequences of those actions. Bandura (1986) later refined this concept through his model of *Triadic Reciprocal Determinism*, emphasizing that behavior, personal factors, and environmental influences interact dynamically to shape human learning and adaptation. Within academic discourse, this framework underscores that learning is both a psychological and social process that evolves through feedback loops, reflection, and environmental reinforcement. In environmental and maritime studies, Social Learning Theory provides a valuable analytical lens to understand how individuals, communities, and institutions collectively learn to adapt to ecological changes and governance challenges. Pahl-Wostl (2009) asserts that social learning is essential for transforming environmental governance, as it enables stakeholders to share experiences, negotiate priorities, and build a common understanding of sustainability. This process is evident in the case of Karimun Besar, where maritime agencies such as BAKAMLA, KPLP, and POLAIRUD, together with organizations like BMKG, KLHK, and IOJI, engage in both formal and informal learning exchanges to address the socio-ecological impacts of marine sediment mining.



Knowledge transfer occurs through digital data sharing, inter-agency coordination, and the integration of local ecological knowledge (LEK) from fishing communities, reflecting the participatory and contextual nature of learning.

A key mechanism within Social Learning Theory is reinforcement, which refers to how behaviors are strengthened or diminished through social feedback and normative validation. Rebellon (2006) emphasizes that reinforcement is not limited to direct rewards or punishments but also involves relational and interpretive processes that shape institutional behavior. In maritime governance, reinforcement is manifested when successful practices—such as data-sharing platforms, mangrove rehabilitation programs, or open-access monitoring systems—are adopted and replicated across agencies, fostering a culture of collaboration and ecological responsibility. This dynamic illustrates that learning within governance systems occurs through observation, emulation, and collective reflection. Furthermore, Social Learning Theory aligns closely with constructivist and cognitive paradigms, as it conceptualizes learning as the co-construction of knowledge through interaction and adaptation (Heyes, 2012). In maritime higher education, for example, institutions like the Universitas Pertahanan RI serve as catalysts of social learning by integrating theory, policy, and community engagement to cultivate adaptive leadership and environmental literacy among future maritime professionals.

From an academic perspective, Social Learning Theory enriches interdisciplinary research on eco-maritime governance by illustrating how knowledge diffusion, behavioral imitation, and institutional feedback mechanisms contribute to adaptive capacity and resilience. Through continuous cycles of observation, reflection, and innovation, maritime actors can strengthen cooperative responses to non-traditional security challenges such as illegal fishing, resource depletion, and sediment mining. Ultimately, the theory reinforces the principle that sustainable maritime governance depends not only on regulatory frameworks but also on collective learning, shared values, and the institutionalization of ecological ethics. In this sense, Social Learning Theory provides both a conceptual foundation and an operational model for achieving Indonesia's vision of a *Global Maritime Fulcrum* through the integration of environmental stewardship, social participation, and security collaboration.

CONNECTIVISM'S IMPLICATIONS FOR TEACHING AND LEARNING

1. Networked Knowledge Integration.

Learning environments must be designed to connect diverse information sources, enabling students to access, analyze, and synthesize data from multiple digital and institutional



networks. Knowledge is distributed across nodes—people, databases, and technological systems—and learning effectiveness depends on the learner’s ability to navigate and update these connections dynamically.

2. Role of Facilitators as Network Guides.

Educators shift from being information providers to learning facilitators who help students build and manage meaningful learning networks. Their role involves supporting learners in evaluating information credibility, fostering digital literacy, and encouraging collaboration across academic and professional communities.

3. Technology as a Cognitive Extension

Digital platforms are no longer supplementary tools but integral components of cognition and knowledge creation. The design of online learning environments should integrate adaptive, data-driven technologies that mirror real-world problem-solving—especially in maritime and environmental studies where real-time data interpretation is essential.

4. Continuous Learning through Connectivity

Connectivism emphasizes that learning is a lifelong and continuous process shaped by technological evolution. Institutions should encourage flexible learning pathways where students can engage in open-access courses, digital forums, and professional networks that extend beyond formal education settings.

5. Adaptive Curriculum and Institutional Collaboration

Educational programs should evolve in response to global and technological changes. Universities and training centers must collaborate across disciplines and borders, creating a knowledge ecosystem that supports co-learning, innovation, and sustainability—particularly in fields like maritime governance and environmental security.

CONSTRUCTIVISM'S IMPLICATIONS FOR TEACHING AND LEARNING

1. Learning as an Active Construction of Meaning

Constructivism emphasizes that knowledge is not transmitted but *actively constructed* by learners through engagement with real-world problems and reflection on experience. In maritime education, this means that students must critically analyze ecological, social, and legal aspects of marine sediment mining rather than memorizing facts. Learning activities such as document analysis, policy debates, and simulation of inter-agency coordination foster deeper understanding of complex maritime security issues.

2. Contextual and Experiential Learning



Teaching should be grounded in authentic maritime contexts that allow learners to connect theory with practice. Case studies like the Karimun Besar sediment mining issue enable students to experience how environmental degradation, governance, and non-traditional security intersect. Such experiential approaches help learners internalize knowledge by directly linking classroom discussions with field realities and policy applications.

3. Collaborative Knowledge Building

Constructivism positions learning as a *social process* where meaning emerges through interaction, dialogue, and collaboration. In maritime governance education, teamwork among students from different disciplines—law, environmental science, and defense studies—encourages the co-construction of solutions to multidimensional maritime challenges. Group projects, joint research, and stakeholder workshops exemplify collaborative learning that mirrors real-world interagency coordination among BAKAMLA, KPLP, and POLAIRUD.

4. Instructor as Facilitator of Reflection and Inquiry

In a constructivist learning environment, the role of the teacher evolves from that of an information transmitter to a *facilitator of inquiry*. Instructors guide students to question assumptions, evaluate evidence, and develop their own conceptual frameworks. For instance, maritime lecturers can facilitate reflective discussions on environmental ethics, sustainability, and geopolitical implications of resource exploitation—helping students construct personalized and critical perspectives.

5. Integration of Cultural and Local Knowledge Systems

Constructivism supports the incorporation of local ecological knowledge (LEK) and community experiences as valid sources of understanding. In the Karimun Besar context, the lived experiences of fishermen, coastal villagers, and local authorities become learning materials that help students grasp the human dimensions of environmental security. Integrating traditional maritime wisdom with modern scientific approaches fosters culturally responsive learning and strengthens students' appreciation of Indonesia's maritime identity.

DISCUSSION

The findings of this study reveal that marine sediment mining in Karimun Besar Island represents a multidimensional challenge involving environmental degradation, social inequality,



and maritime security fragility. Continuous dredging and unregulated exploitation have significantly altered the geomorphology of the seabed, reduced mangrove coverage, and increased coastal erosion, confirming the analysis by Sofiyani et al. (2012) and Lestari et al. (2023) that intensive sand mining disturbs sediment balance and degrades ecosystem resilience. This environmental deterioration not only threatens biodiversity but also weakens the socio-economic structure of coastal communities whose livelihoods depend on fisheries and coastal ecosystems.

From a governance perspective, the research highlights persistent institutional fragmentation and weak coordination among maritime agencies. The overlapping jurisdictions of BAKAMLA, KPLP, and POLAIRUD have limited the effectiveness of marine surveillance and law enforcement, echoing IOJI's (2024) report on the absence of a unified *eco-maritime security governance* framework. The limited integration of environmental data across agencies further constrains Maritime Domain Awareness (MDA), hindering real-time response to illegal dredging and cross-border activities. This situation exemplifies the *governance gap* between policy formulation and implementation, where environmental protection and maritime security are treated as separate domains rather than interconnected components of national resilience.

In the socio-environmental dimension, the degradation of coastal ecosystems has intensified non-traditional security threats such as illegal fishing, smuggling, and localized conflicts. The erosion of natural habitats undermines food security and triggers economic displacement, reinforcing the argument of Bueger (2015) that maritime insecurity often arises from environmental decline rather than military conflict. Social Learning Theory (Bandura, 1977; Pahl-Wostl, 2009) helps explain the behavioral dynamics of both communities and institutions in adapting to environmental change. Local actors tend to model behaviors from peers and authorities; hence, weak institutional responses and lack of community engagement perpetuate unsustainable practices.

Constructivist and connectivist perspectives also shed light on the transformation of maritime education and governance. Constructivism emphasizes that knowledge is co-created through dialogue and experience, which is crucial for building shared environmental awareness among agencies and communities. Meanwhile, Connectivism (Siemens, 2005) underscores the importance of digital connectivity in linking environmental data, institutional knowledge, and public participation. Together, these theories suggest that effective maritime governance in the digital era requires both cultural adaptation and technological integration. The transition from analog and isolated systems toward open, connected, and participatory networks—as illustrated in the *super system shift* analysis—marks Indonesia's strategic move toward data-driven and



collaborative maritime security governance.

Ultimately, this discussion demonstrates that addressing the ecological and social consequences of marine sediment mining demands not only regulatory enforcement but also continuous learning, cross-institutional cooperation, and cultural evolution in maritime governance. Integrating *eco-maritime security governance* within educational institutions such as Universitas Pertahanan RI ensures that future policymakers, officers, and researchers develop holistic competencies that align environmental sustainability with national security objectives.

CONCLUSION

This study concludes that marine sediment mining in Karimun Besar Island has generated profound ecological and socio-political implications that extend beyond environmental degradation. The destruction of seabed structures, mangrove loss, and shoreline erosion have disrupted coastal stability, leading to declining fishery productivity and increased social vulnerability among local communities. These environmental disruptions have also triggered non-traditional maritime security concerns, including illegal resource exploitation, smuggling, and diminished state presence in border waters.

Institutional responses remain constrained by fragmented authority and limited technological integration among maritime enforcement agencies. The absence of a coordinated *Maritime Security Coordination Framework* reduces operational efficiency and weakens maritime domain awareness. Therefore, the study recommends strengthening inter-agency synergy through a unified *Eco-Maritime Security Governance* model supported by digital data-sharing systems, standard operating procedures for joint patrols, and a proposed *Joint Maritime Operation Center (JMOC)* in strategic regions such as Karimun Besar.

From a theoretical standpoint, the research confirms that constructivist, social learning, and connectivist approaches collectively provide a robust foundation for understanding adaptive governance in maritime contexts. These frameworks highlight that sustainable maritime management depends not only on institutional control but also on continuous learning, collaboration, and cultural adaptation. By embedding these principles into maritime education and policy frameworks, Indonesia can foster a new generation of maritime leaders capable of integrating ecological protection, social participation, and national security—realizing the nation's long-term vision as a Global Maritime Fulcrum.



FUTURE DIRECTIONS

The study opens several pathways for future research and policy development in the domain of eco-maritime security governance. Future investigations should aim to deepen the empirical understanding of how environmental degradation, socio-economic vulnerability, and maritime governance interact dynamically in border regions such as Karimun Besar. Quantitative and spatial analyses—combining satellite imagery, GIS-based coastal modeling, and socio-economic data mapping—can provide more precise insights into the long-term impacts of sediment mining on coastal morphology and community resilience. Integrating such approaches with qualitative fieldwork would enable a more comprehensive and evidence-based understanding of non-traditional maritime security threats.

Secondly, further studies should explore inter-agency learning systems through the lens of Social Learning Theory and Constructivism. Longitudinal research on inter-organizational collaboration between BAKAMLA, KPLP, POLAIRUD, and KLHK could identify institutional barriers and opportunities for sustainable knowledge exchange. Building digital knowledge-sharing platforms and simulation-based training modules would enhance mutual understanding, encourage adaptive policy behavior, and institutionalize collaborative maritime governance. This future direction aligns with Indonesia's vision to strengthen its *Maritime Domain Awareness (MDA)* framework through innovation and cross-sectoral learning.

Third, research should also focus on educational transformation within maritime higher education institutions. Applying Connectivism in curriculum design can help build *networked learning ecosystems* that integrate environmental science, defense studies, and marine law. Future pedagogical models could emphasize experiential learning, digital simulations, and interdisciplinary teamwork to prepare students for real-world maritime challenges. As higher education shifts from knowledge transmission to co-creation, universities such as Universitas Pertahanan RI can serve as laboratories for developing the next generation of maritime leaders who combine analytical, ecological, and strategic competencies.

Fourth, there is a need to develop policy-oriented research aimed at designing an *Eco-Maritime Security Coordination Framework* that harmonizes environmental, legal, and defense dimensions. Future researchers may use a mixed-methods approach integrating SWOT–AHP (Analytic Hierarchy Process) analysis to prioritize inter-agency strategies for joint surveillance, marine spatial planning, and sustainable resource protection. Establishing a *Joint Maritime Operation Center (JMOC)* in critical areas like Karimun Besar could be tested through pilot studies to evaluate its feasibility and inter-operability in real maritime enforcement contexts.



Finally, future research should investigate the cultural and behavioral transformation required to sustain eco-maritime governance. Drawing on Cultural Evolution Theory and Social Learning frameworks, studies can assess how local knowledge, societal norms, and technological adaptation shape long-term ecological responsibility among coastal communities. Comparative analyses between different Indonesian maritime regions—such as Natuna, Batam, and Karimun—could yield valuable policy insights into how regional governance models adapt to global environmental and security trends.

Collectively, these future directions highlight the importance of an integrated, interdisciplinary, and participatory approach to maritime security research and education. By combining technological innovation, institutional learning, and community engagement, future scholars and policymakers can advance a comprehensive framework that secures Indonesia's maritime environment while strengthening its national resilience and regional leadership in the Indo-Pacific.

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