



Deconstructing the "Kolam Susu" Complacency: A Critical Review on the Urgency of On-Board Meteorological Equipment for Navigation Safety in Indonesia

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Abstract. Popularized by a legendary national song, the phrase "Kolam Susu" (Ocean of Milk) has unintentionally fostered a deeply ingrained complacency among Indonesian seafarers, under the assumption that domestic tropical waters are inherently calm and safe. However, recurring maritime casualties caused by sudden, localized extreme weather events paint a starkly different and tragic reality. This literature review addresses a critical safety blind spot in the Indonesian maritime sector: the widespread absence of functional meteorological equipment aboard domestic commercial and passenger vessels. Despite explicit mandates under SOLAS Chapter V (Regulation 5), IMO guidelines, and Indonesia's Shipping Act No. 17 of 2008, a majority of domestic vessels still operate without essential weather-tracking instruments. Consequently, crews remain passive and vulnerable consumers of macro-level shore forecasts rather than active contributors to real-time, localized marine observation. By synthesizing global legal frameworks, national regulations, and maritime accident case studies, this paper deconstructs the structural and cultural roots of this weather complacency. The analysis emphasizes that rapid convective atmospheric shifts in archipelagic waters require immediate, vessel-level tracking that cannot be replaced by distant land-based data. This study serves as an urgent advocacy campaign to revitalize meteorological consciousness among regulators, shipowners, and operators. Ultimately, equipping domestic vessels with proper meteorological tools is not a financial or bureaucratic burden; it is an indispensable life-insurance mechanism and a statutory requirement to ensure true seaworthiness (*kelaiklautan*) in Indonesian waters.

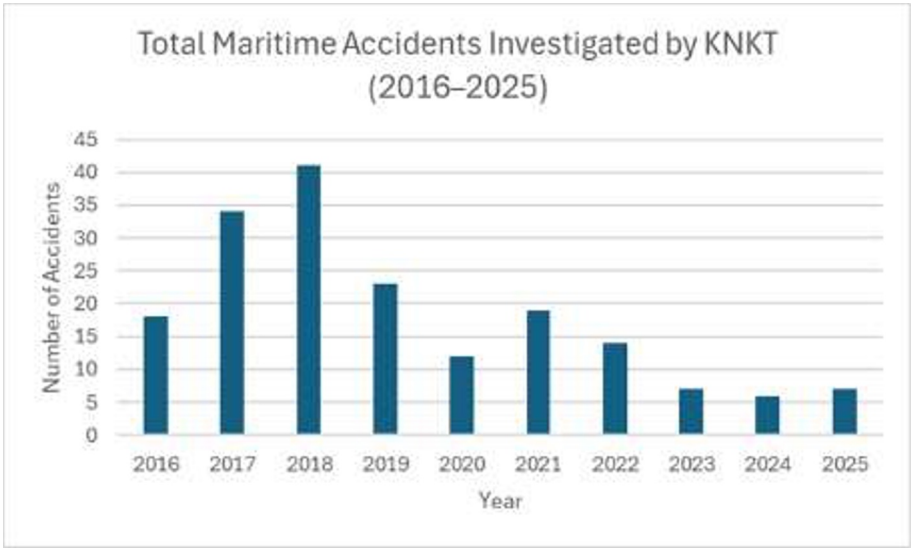
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1. INTRODUCTION

Indonesia's geographical nature as the world's largest archipelagic state dictates an absolute reliance on domestic shipping corridors for socioeconomic integration and inter-island connectivity. Culturally, this vast maritime expanse is frequently perceived through an illusion of permanent serenity, a safety mindset historically reinforced by the cultural trope of "Kolam Susu" (a pool of milk) implying inherently safe, calm

equatorial waters. However, maritime operational reality severely contradicts this romanticized complacency. Tropical archipelagic perimeters are subjected to highly volatile meteorological dynamics, where rapid convective developments, sudden squalls, and localized atmospheric shifts frequently trigger severe maritime casualties (Medda et al., 2024). The destructive potential of these rapid equatorial weather anomalies is empirically demonstrated in recent accident analyses, where sudden intensification of tropical weather systems has caused catastrophic anchor-dragging accidents and structural vessel failures (Chen et al., 2025).

To empirically deconstruct the cultural illusion of permanent maritime serenity, Figure 1 presents the total number of shipping accidents investigated by the National Transportation Safety Committee (KNKT) from 2016 to 2025. The statistical trend shows a severe escalation of maritime casualties in the earlier years of the decade, peaking dramatically in 2018 with 41 major investigated accidents. While a positive downward trend is observed in the subsequent years—gradually stabilizing at 7 cases in 2023, 6 cases in 2024, and 7 cases in 2025—the persistent recurrence of these disasters demonstrates that Indonesian waters are far from static or inherently safe. These figures indicate that despite advancements in vessel technology and hull construction, ships navigating the Indonesian archipelago remain continuously exposed to severe operational risks, where sudden tropical weather anomalies often act as a critical compounding factor behind these recorded casualties.



Source: *knkt.go.id*

Figure 1. Total maritime accidents investigated by the Indonesian National Transportation Safety Committee (KNKT) from 2016 to 2025

To mitigate these dynamic environmental hazards, the international maritime community has established strict legal frameworks governing meteorological compliance. Under the International Convention for the Safety of Life at Sea (SOLAS)

Chapter V, Regulation 5, contracting governments and vessel operators are legally mandated to maintain and encourage the collection of meteorological data for navigation safety (IMO, 1974). This global safety standard is operationalized through the Maritime Safety Information (MSI) Service (IMO, 2019) and structured under the World Meteorological Organization's mandatory guidelines for marine observations (WMO, 2024). Furthermore, the joint IMO/WMO Worldwide Met-Ocean Information and Warning Service emphasizes that vessels must function as active sensory nodes within global safety networks rather than passive data consumers (NeRF, 2011).

On a national scale, Indonesia has strictly aligned its statutory architecture with these global conventions. The primary legal backbone, Undang-Undang Nomor 17 Tahun 2008 tentang Pelayaran, explicitly dictates that vessel seaworthiness (*kelaiklautan*) fundamentally encompasses the operational readiness of navigation and meteorological instruments (UU RI 17, 2008). This safety baseline has been further strengthened through the latest statutory update, Undang-Undang Nomor 66 Tahun 2024 (the third amendment of the Shipping Act), which intensifies compliance enforcement and penalties for maritime safety failures (UU RI 66, 2024). Despite this robust legislative framework, a critical enforcement gap persists within Indonesia's domestic and pioneering (*perintis*) fleets, where a significant portion of vessels continue to navigate without functional on-board weather tracking tools.

This widespread absence of shipborne instruments creates a dangerous "data vacuum" at sea. Land-based macro-forecasts are inherently limited in capturing micro-scale, localized convective marine weather shifts. Conversely, shipborne observations, such as real-time along-track wind and wave monitoring, provide high-fidelity diagnostics paramount for immediate hazard evasion and weather routing (Wang et al., 2023; Jia et al., 2025). Historically, the primary barrier to equipping domestic vessels was the high cost of specialized hardware. However, recent breakthroughs in Indonesian maritime engineering demonstrate that reliable, smart-sensor-equipped Vessel Automatic Weather Stations (VAWS) can now be deployed cost-effectively utilizing Internet of Things (IoT) frameworks (Furqon et al., 2025). Therefore, financial non-viability is no longer a valid excuse for non-compliance. This paper presents a critical review to deconstruct the cultural weather complacency in Indonesia and advocates for a rigorous revitalization of on-board meteorological awareness among all maritime stakeholders.

2. METHODOLOGY

This study emotionalizes a qualitative and critical literature review approach to systematically analyze the structural enforcement gaps, legal frameworks, and cultural factors surrounding shipborne meteorological equipment compliance in Indonesia. Unlike a standard systematic review that strictly aggregates statistical data, a critical review method allows for the evaluation of existing conceptual models, leading to a synthesized, solution-oriented advocacy framework. The operational research design is structured into three distinct, interconnected analytical phases.

Phase 1: Regulatory Mapping and Statutory Analysis. The initial phase involves a rigorous archival and comparative analysis of existing international conventions and national laws. The global safety baseline is examined through the statutory mandates of the International Convention for the Safety of Life at Sea (SOLAS) Chapter V,

Regulation 5 (IMO, 1974), the operational guidelines of the Maritime Safety Information (MSI) Service (IMO, 2019), and the meteorological standards outlined in the Guide to Marine Meteorological Services (WMO, 2024). These international benchmarks are directly contrasted with Indonesian national legislation, specifically Undang-Undang Nomor 17 Tahun 2008 tentang Pelayaran (UU RI 17, 2008) and its latest legislative update, Undang-Undang Nomor 66 Tahun 2024 (UU RI 66, 2024), to evaluate the explicit legal definitions and execution of vessel seaworthiness (kelaiklautan).

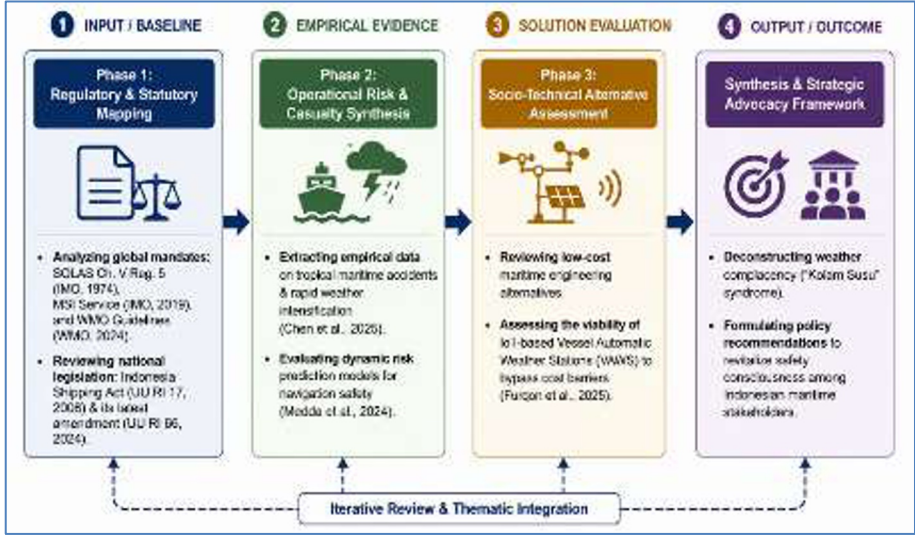


Figure 2. Operational research framework flowchart of the critical literature review process.

Phase 2: Empirical Risk and Casualty Synthesis. To counter the subjective cultural complacency associated with the "Kolam Susu" mindset, the second phase synthesizes empirical evidence from recent maritime safety literature (2021–2026). High-impact academic databases—specifically Scopus, IEEE Xplore, and ScienceDirect—were queried to extract case studies regarding weather-related maritime disasters. Literature evaluating dynamic risk prediction models for maritime accidents (Medda et al., 2024) and quantitative analyses of rapid tropical weather intensification causing severe ship failures (Chen et al., 2025) were analyzed. This empirical data serves to scientifically demonstrate the absolute necessity of real-time, vessel-level atmospheric tracking.

Phase 3: Socio-Technical and Solution Evaluation. The final phase addresses the socioeconomic justification commonly used by domestic operators to bypass instrument compliance—namely, the high cost of marine hardware. This stage reviews recent domestic technological breakthroughs in affordable maritime engineering. Specifically, the technical viability, architectural accessibility, and cost-efficiency of low-cost Vessel Automatic Weather Stations (VAWS) utilizing Internet of Things (IoT) frameworks and smart sensors (Furqon et al., 2025) were evaluated against traditional, high-cost meteorological suites.

The qualitative insights extracted from these three phases are integrated through thematic synthesis to construct a strategic advocacy model. This model provides actionable recommendations to realign safety consciousness among Indonesian regulators, shipowners, and shipboard officers.

3. DISCUSSION

3.1 The "Kolam Susu" Illusion vs. Empirical Evidence of Tropical Maritime Risks

The cultural trope of "Kolam Susu" induces a deceptive psychological safety margin among domestic maritime operators, assuming equatorial waters are immune to the catastrophic cyclonic forces seen in higher latitudes. However, atmospheric physics in archipelagic tropical zones dictates a highly volatile environment characterized by rapid convective developments, localized squalls, and sudden barometric drops. The structural danger of this complacency is highlighted by recent maritime risk models, which demonstrate that environmental and meteorological variables are dynamic, compounding risk factors that directly accelerate ship accident probabilities (Medda et al., 2024).

Furthermore, the vulnerability of vessels operating without localized, real-time weather data is empirically proven in recent casualty investigations. For instance, quantitative analyses of rapid intensification in tropical cyclone systems show that severe maritime accidents—such as catastrophic anchor dragging and sudden loss of vessel stability—frequently occur because vessels fail to detect micro-scale atmospheric warning signs until it is too late (Chen et al., 2025). The historical data from the Indonesian National Transportation Safety Committee (KNKT) displayed in Figure 1 underscores that accidents remain persistent, proving that relying on the illusion of permanently calm tropical perimeters is a critical flaw in modern navigation safety management.

3.2 De Jure Statutory Mandates vs. De Facto Data Vacuum

The persistent absence of on-board meteorological equipment aboard Indonesian domestic and pioneering (perintis) fleets represents not just a safety hazard, but a profound violation of both international conventions and national laws. Under global maritime safety standards, shipborne meteorological reporting is a strict statutory duty. Table 1 synthesizes the existing international and national legal structures that govern this compliance.

Despite this clear legal framework, a massive *de facto* enforcement gap exists. Most domestic vessel operators treat weather monitoring as a passive, shore-centric obligation, relying solely on macro-forecasts from the state agency (BMKG). This breaks the vital safety feedback loop. As established by global safety networks, a vessel must act as an active sensor; without shipborne logging, a severe data vacuum is created across remote inter-island shipping lanes, directly impairing localized early warning accuracy.

Table 1. Legal Instruments and Operational Requirements for Shipborne Weather Tools

Regulatory Level	Legal Instrument	Statutory Requirement & Expectation
International	SOLAS Chapter V, Regulation 5 (IMO, 1974)	Mandates contracting governments to encourage the collection and dissemination of meteorological data by vessels at sea.
International	MSI Service, Annex to MSC.1/Circ.1610 (IMO, 2019)	Defines ship-to-shore meteorological observation as a core component of the global Maritime Safety Information infrastructure.
International	Guide to Marine Meteorological Services (WMO, 2024)	Establishes technical standards for the calibration, placement, and operation of shipboard atmospheric sensors.
International	Resolution A.1051(27) (NeRF, 2011)	Outlines the operational framework for the Worldwide Met-Ocean Information and Warning Service, treating vessels as active monitoring nodes.
National	<i>Undang-Undang Pelayaran</i> No. 17 Year 2008 (UU RI 17, 2008)	Explicitly defines vessel seaworthiness (<i>kelaiklautan</i>) as encompassing the mandatory operational readiness of navigation and meteorological tools.
National	<i>Undang-Undang Pelayaran</i> No. 66 Year 2024 (UU RI 66, 2024)	Strengthens legal enforcement mechanisms, updates compliance parameters, and increases administrative penalties for safety instrument failures.

3.3 The Value of Shipborne Observations and Technological Accessibility

To rebuild meteorological consciousness, stakeholders must understand that land-based or satellite-projected data cannot fully substitute immediate, vessel-level atmospheric tracking. Empirical studies in marine remote sensing confirm that shipborne Global Navigation Satellite System (GNSS) instruments provide significantly higher fidelity in diagnosing local water vapor anomalies and predicting typhoon or severe storm responses directly along the ship's track compared to distant land stations (Jia et al., 2025). Furthermore, real-time shipborne sensors tracking significant wave heights and wind speeds are paramount for accurate weather routing and hazard avoidance in volatile corridors (Wang et al., 2023).

The historical defense utilized by domestic shipowners to bypass this instrumentation mandate has been the prohibitive cost of importing marine-grade weather stations. However, recent advancements in domestic maritime technology completely nullify this economic objection. Local engineering breakthroughs have proven that highly accurate, networked maritime weather observation systems can be custom-designed for typhoon-prone and tropical environments (Chen et al., 2026).

More importantly, cost-effective Vessel Automatic Weather Stations (VAWS) built upon open-source Internet of Things (IoT) architectures and integrated smart sensors are now fully developed and tested within Indonesia (Furqon et al., 2025). Figure 3 illustrates the basic operational architecture of such low-cost systems, demonstrating a continuous data flow from shipborne sensor arrays to a centralized processing unit on the bridge, allowing for local real-time visualization and simultaneous transmission to cloud-based servers via standard Internet protocols. These IoT-enabled units offer automated data archiving directly from the ship's deck to the bridge at a fraction of traditional hardware costs. Consequently, with the legislative backing of the newly enacted Undang-Undang Pelayaran No. 66 of 2024 (UU RI 66, 2024), regulators possess both the legal authority and the technological means to enforce mandatory compliance, ensuring that no domestic vessel leaves port "blind" to the shifting tropical skies.

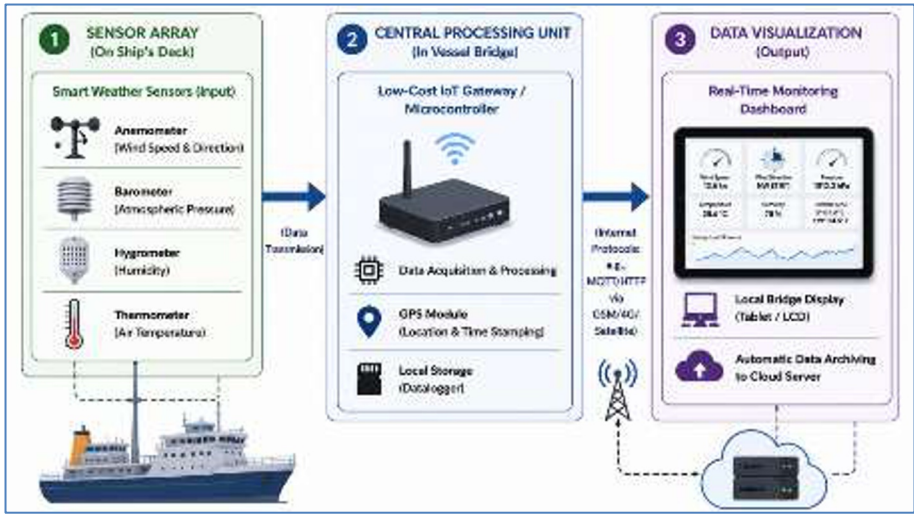


Figure 3. Operational architecture of a low-cost, networked Vessel Automatic Weather Station (VAWS) utilizing IoT and smart sensor frameworks (Adapted from Furqon et al., 2025).

4. CONCLUSION

The romanticized "Kolam Susu" cultural trope represents a dangerous psychological complacency that severely undermines navigation safety within the Indonesian shipping sector. This critical review has demonstrated that equatorial archipelagic waters are far from inherently serene; rather, they are subjected to rapid, highly volatile convective atmospheric shifts and localized micro-scale anomalies that land-based macro-forecasts fail to capture. Navigating these waters without localized, vessel-level detection tools expose crews, passengers, and cargo to unacceptable operational risks, as validated by persistent maritime casualty trends recorded by the KNKT.

From a regulatory standpoint, the widespread absence of shipborne meteorological instruments across domestic and pioneering fleets constitutes a profound enforcement failure. It directly violates longstanding global safety frameworks under SOLAS Chapter V (Regulation 5) and IMO/WMO operational service standards, while simultaneously undermining national mandates explicitly codified in Indonesia's Shipping Act (Undang-Undang Pelayaran) No. 17 of 2008 and its rigorous 2024 amendment (Undang-Undang Pelayaran No. 66 of 2024). True vessel seaworthiness (kelaiklautan) cannot be decoupled from meteorological readiness.

To bridge this critical safety gap, the historical socio-economic defense of high hardware costs is no longer tenable. Recent domestic maritime engineering innovations have successfully pioneered affordable, smart-sensor-equipped Vessel Automatic Weather Stations (VAWS) built upon open-source Internet of Things (IoT) frameworks. Therefore, a coordinated policy paradigm shift is urgently required: maritime regulators must strictly enforce instrument compliance under the statutory backing of UU RI No. 66 of 2024, and shipowners must proactively adopt these low-cost localized solutions. Transforming Indonesian domestic vessels from passive data consumers into active, networked meteorological observing nodes is the ultimate key to dismantling weather complacency and achieving true zero-accident navigation safety across the archipelagic highways.

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