

Study of Legal and Technical Aspect on Sedimentation Management in Indonesia Seas

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ABSTRACT

Dredging and marine sand export activities in Indonesia have raised concerns about their impacts on marine environmental quality and regulatory certainty in sedimentation management. This study examines the legal and technical aspects of marine sedimentation management policies, focusing on the implementation of Government Regulation No. 26 of 2023 on Marine Sedimentation Management and Government Regulation No. 31 of 2021 on Shipping. The legal review evaluates the coherence of these regulations with higher legal frameworks, including Law No. 32 of 2014 on Marine Affairs, the Job Creation Law, the United Nations Convention on the Law of the Sea (UNCLOS 1982), and international standards from the Oslo-Paris (OSPAR) Convention. The analysis reveals that PP 26/2023 and PP 31/2021 still exhibit vertical inconsistencies, overlapping institutional mandates, and limited alignment with international marine governance principles. Technically, this study analyzes changes in water turbidity using Sentinel-2 satellite imagery and the Normalized Difference Turbidity Index (NDTI) across four priority areas: Pulau Karimun Besar, Demak Regency, Kutai Kartanegara Regency, and Surabaya City. The findings indicate a strong, statistically significant correlation between NDTI values and marine sand export volume in Pulau Karimun Besar ($r = 0.99$; $p = 0.0005$), while other locations show weaker, non-significant correlations. These results highlight the need to integrate legal reform with spatially informed technical monitoring to enhance sustainable sedimentation management in Indonesia's coastal waters.

Keywords: Marine Sand Export; Sedimentation Management; Legal Aspect; Technic Aspect.

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INTRODUCTION

Indonesia has engaged in marine sand export since 1976, with Singapore being one of the primary beneficiaries by using sand, particularly from the Riau Islands Province, for land reclamation purposes (Ernawati et al., 2025; Yansen et al., 2023). However, this activity raised sovereignty concerns, especially with the degradation of Nipa Island, which hosts the TR190 reference point used in maritime boundary delimitation between Indonesia and Singapore (Maghfur & Al Firdaus, 2025).

To address these issues, the Indonesian government imposed an export ban in 2003 through the Decree of the Minister of Marine Affairs and Fisheries No. 28/SE/K4TP4L/II/2003 and the Decree of the Minister of Industry and Trade No. 117/MPP/Kep/2/2003. These regulations aimed to prevent further environmental degradation, such as the submergence of small islands near the national borders, and to address unresolved maritime boundary disputes (Dwi Lestari Indah Sari, 2023).

Despite the ban, marine sand exports continued, as reflected in post-2003 data from the (UN Comtrade Database, 2025), suggesting the presence of illegal sand mining activities. Instead of strengthening enforcement, the government reauthorized marine sand exports through the enactment of Government Regulation No. 26 of 2023 (PP/26/2023), which triggered public debate and environmental concerns (Maghfur & Al Firdaus, 2025).

Subsequently, the Supreme Court of Indonesia, through Decision No. 5/P/Hum/2025, reviewed Articles 10(2), 10(3), and 10(4) of PP/26/2023, which permitted commercial marine sand utilization. The Court ruled that these provisions conflict with Article 56 of the Marine Affairs Law (Law No. 32/2014), which mandates the protection of the marine environment through prevention, reduction, and control of pollution.

In addition to Government Regulation No. 26 of 2023 (PP/26/2023), Indonesia also enforces Government Regulation No. 31 of 2021 (PP/31/2021) concerning the Implementation in the Field of Shipping, which governs the management of dredged material specifically in navigation channels and port areas (Butt & Lindsey, 2018; Nugraha et al., 2021). Notably, PP/31/2021 permits the commercial utilization of dredged sediments (Kurniawan & Prasetyo, 2020). The coexistence of these two regulations reflects regulatory inconsistency and has contributed to legal uncertainty in the governance of marine sediment utilization in Indonesia (Gunningham et al., 2017; Setiawan & Wibowo, 2022).

Separately, the Government of Indonesia has designated Morodemak Waters as a pilot site for marine sediment management in 2024. A study by Maghfur & Al Firdaus (2025) reveals divergent views among the Morodemak community some support dredging to reopen fishing access routes, provided that the dredged material benefits their village, others express concern that such activities could exacerbate coastal flooding due to sea-level rise. In addition to Morodemak, other priority sites have been identified through the Ministerial Decree of Marine and Fisheries No. 208 of 2023 (Kepmen KP 208/2023) on Priority Locations for Marine Sediment Management, including Pulau Karimun Besar in Riau Islands Province, Kutai Kartanegara Regency, and Surabaya City.

In response to these developments, this study aims to assess the alignment of current national regulations with the United Nations Convention on the Law of the Sea (UNCLOS 1982) regarding the commercial use of sediment (Kurnia Ida, 2008), as well as with international standards under the Oslo-Paris Convention (OSPAR) related to dredged material management (Ausili et al., 2022; Pilipović et al., 2025). In addition, this study analyzes changes of turbidity from 2021 to 2024 at priority locations using Sentinel-2A satellite imagery, employing the Normalized Difference Turbidity Index (NDTI) as the primary parameter (Ardyan, 2025; Sankaran et al., 2023).

METHOD

This study employed a mixed-methods approach, combining legal analysis and remote sensing-based technical analysis. The legal aspect focused on analyzing Indonesia's regulatory framework governing the utilization of marine sediment. Relevant legal documents included national regulations such as Law No. 32 of 2014 on Marine Affairs, the Job Creation Law, and Government Regulations No. 26 of 2023 and No. 31 of 2021. These were compared with international instruments, notably UNCLOS 1982 and the OSPAR Convention on the Management of Dredged Material at Sea. The analysis assessed coherence and alignment between national policies and international standards, particularly regarding the commercial use of dredged sediment.

The technical aspect analyzed changes in turbidity using satellite imagery from Sentinel-2A for the years 2021–2024. The analysis covered four priority areas designated by the Indonesian government. The imagery was first filtered using cloud masking, after which annual

median composites were generated using bands 3 (Red), 4 (Green), and 8 (NIR). NDTI and Normalized Difference Water Index (NDWI) were computed to isolate water bodies and quantify turbidity levels. Annual mean NDTI values were extracted for each location, and trends were analyzed over time.

A correlation analysis was conducted between NDTI values and marine sand export data to examine the relationship between observed turbidity and human activities. The combined results from both the legal and technical analyses were used to formulate policy recommendations for sustainable sediment management. The study areas were the four priority areas designated by the Indonesian government: Karimun Besar (Fig. 1), Demak Regency (Fig. 2), Kutai Kartanegara Regency (Fig. 3), and Surabaya City (Fig. 3).

RESULTS AND DISCUSSION

Identification Legal Aspect on Commercial Utilization of Sediment

A review of key regulations reveals provisions supporting commercial sediment use (Table 1) and those ensuring marine environmental protection (Table 2), emphasizing the need for balanced and sustainable policies.

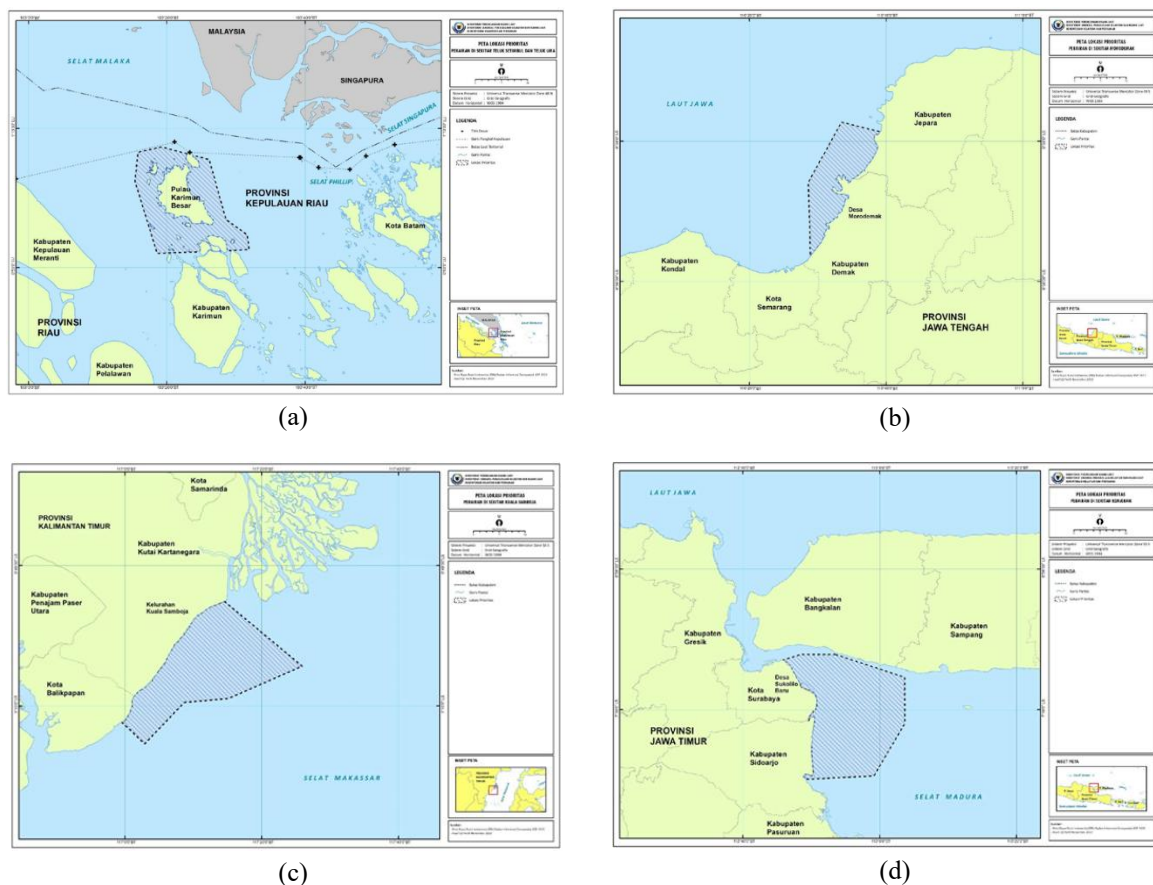


Figure 1. Priority Area - (a) Karimun Besar Island, (b) Demak Regency, (c) Kutai Kartanegara Regency, and (d) Surabaya City
(Source: Kepmen KP No. 208/2023)

Table 1. Regulation that Supports the Commercial Exploitation or Utilization of Dredged Marine Sediment

No	Article	Source
1	193	UNCLOS 1982
2	14, 21, 22	UU/32/2014
3	UU/32/2014: 42 (1b), 47A	UU Cipta Kerja

Table 2. Regulations Concerning the Protection of the Marine Environment

No	Article	Source
1	192, 194 (3a), 194 (3c), 195, 204 (2), 207, 208, 210	UNCLOS 1982
2	50, 52, 55 (1), 56	UU/32/2014
3	UU/32/2014: 42 (1a), UU/27/2007: 17	UU Cipta Kerja

Based on Article 193 of UNCLOS 1982, coastal states have the sovereign right to exploit their natural resources. This is further reinforced by Articles 14, 21, and 22 of Indonesia’s Marine Affairs Law, which mandate the central and regional governments to manage marine resources for public welfare through a blue economy approach. Additional provisions under Articles 42(1b) and 47A amended by the Job Creation Law, explicitly allow the utilization of marine space for national and international scale resource exploitation, including marine mining activities. As marine sediments may be categorized under mineral and coastal resources, their commercial use is legally permissible, as long as it aligns with marine spatial planning policies.

At the same time, legal instruments also emphasize the need to protect the marine environment. Provisions under UNCLOS 1982 and national laws require the government to prevent and control marine pollution, ensure that environmental degradation is not shifted between areas, and adopt international standards in environmental regulation. Therefore, any commercial exploitation of marine sediment must be carefully regulated to balance resource utilization with environmental protection.

Identification Compatibility National Regulation with Sediment Management Standard by OSPAR Convention

Table 3. Analysis of the Alignment Between National Regulations and International Standards

No	Stage	PP/26/2023	PP/31/2021
1	Planning & Data Collection	Partially Aligned	Partially Aligned
2	Sedimentation Control	Not Aligned	Not Aligned
3	Regulated Sediment materials	Partially Aligned	Aligned
4	Determination of dredging specs	Partially Aligned	Not Aligned
5	Selection of sediment utilization options	Partially Aligned	Partially Aligned
6	Permitting	Partially Aligned	Not Aligned
7	Dredging operations (time and duration)	Aligned	Not Aligned
8	Monitoring and evaluation	Partially Aligned	Partially Aligned

In the planning and data collection phase, OSPAR emphasizes direct field surveys to ensure accurate environmental assessments. However, PP/26/2023 permits the use of secondary data through literature reviews, which may reduce accuracy due to the dynamic nature of coastal areas. PP/31/2021 lacks any specific provision for preliminary data collection but requires environmental and spatial conformity permits. In sediment control, OSPAR promotes

identifying sediment sources to minimize the volume requiring dredging. Both PP/26/2023 and PP/31/2021 focus solely on dredging without source identification.

Regarding material classification, OSPAR regulates all sediment types (mud, sand, rocks). PP/26/2023 covers only sand and mud, while PP/31/2021 aligns more with international standards by allowing flexibility based on site conditions. In selecting dredging technology, OSPAR suggests Best Environmental Practice (BEP) based on site conditions. PP/26/2023 mandates the use of advanced suction dredgers but allows alternatives if conditions are unsuitable. PP/31/2021 generically mentions dredging vessels without flexibility.

For sediment reuse, OSPAR prioritizes natural system restoration. PP/26/2023 specifies commercial uses (e.g., reclamation, infrastructure, or export if domestic needs are met), while PP/31/2021 treats dredged sediment as waste, unless economic value is identified. Regarding licensing, OSPAR requires impact modeling and worst-case scenario analysis. PP/26/2023 includes impact assessment in the permit process but sets a high minimum volume threshold (50 million m³), contrary to UNCLOS guidelines. PP/31/2021 focuses on technical compliance with no environmental evaluation, placing full responsibility on permit holders.

In dredging operations, OSPAR recommends scheduling around sensitive ecological periods. PP/26/2023 considers oceanographic conditions and local wisdom. PP/31/2021 lacks such provisions. Finally, in monitoring and evaluation, OSPAR requires compliance checks and impact comparison against initial assessments. PP/26/2023 and PP/31/2021 only monitor implementation volume without assessing environmental effects or validating impact hypotheses.

Correlation Analysis of Export Sea Sand Data with Turbidity at the Priority Location of Sedimentation Management

Based on the average turbidity values observed at the priority locations for marine sediment management, a similar pattern emerges across all sites namely, an increase in turbidity in 2023 followed by a tendency toward clearer waters in 2024 (see fig. 5). Notably, the designation of these priority locations was only formalized through Ministerial Decree of Marine Affairs and Fisheries No. 208 of 2023, which was issued on 29 December 2023.

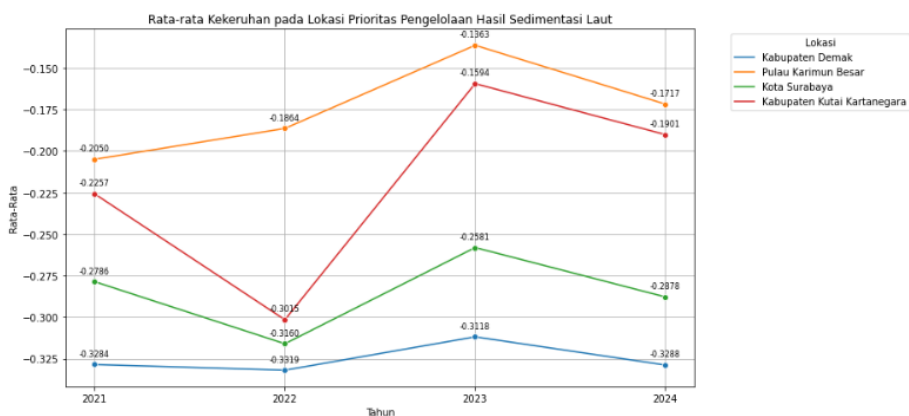


Figure 2. Mean of Turbidity by Years

However, according to export data from the UN Comtrade Database (2025) under HS Code 2505 (natural sand), Indonesia exported sand during the period of 2021 to 2023 (see table

6). When this export data is correlated with the average turbidity values, Pulau Karimun Besar shows a strong and statistically significant correlation with $r = 0.99$ and $p\text{-value} = 0.00056$. Nevertheless, this finding requires further field verification and comparison with other parameters that may influence turbidity levels such as river discharge, shoreline erosion, precipitation, tides, and current and wind speed.

Table 4. Sand Export Indonesia by UN Comtrade Database, HSCODE (2505)

No	Years	Qty (Kg)
1	2021	208.130.000
2	2022	800.377.000
3	2023	2.386.883.563

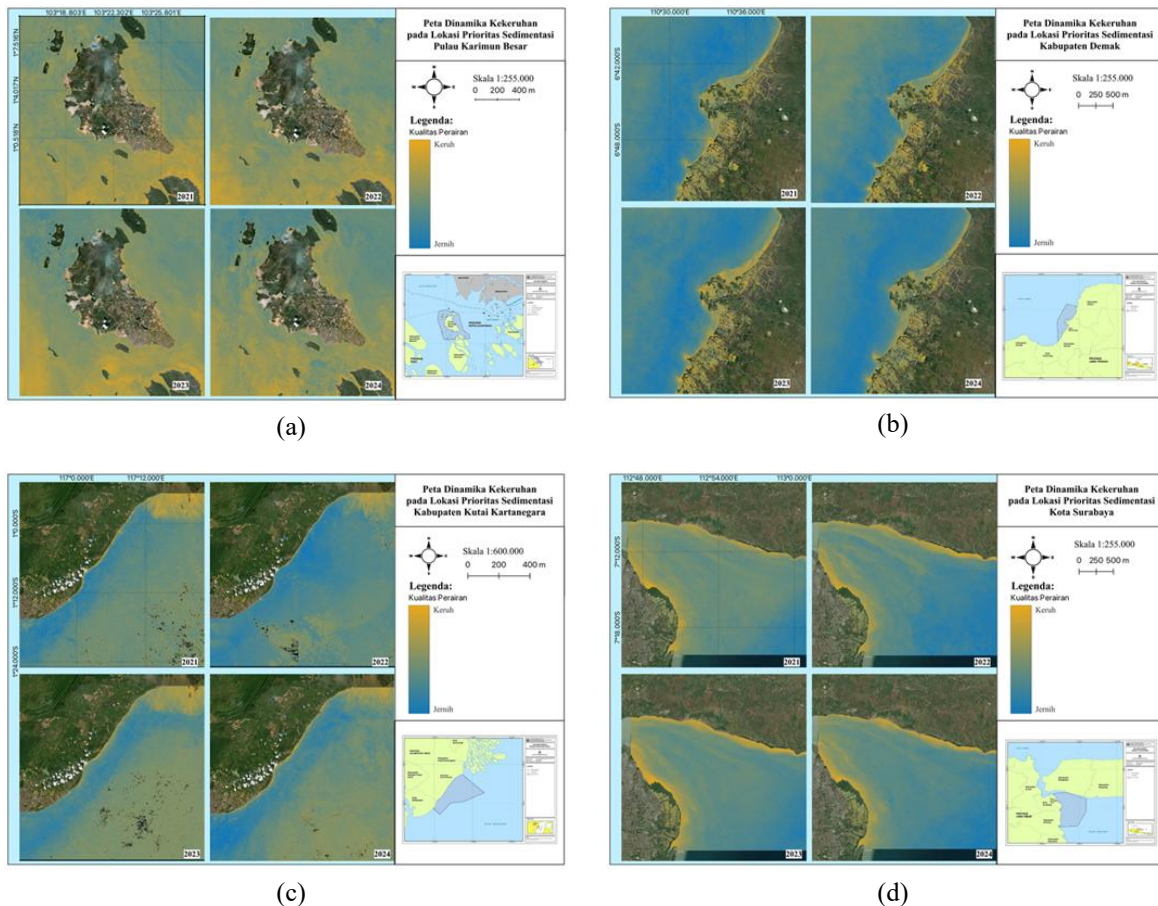


Figure 3. Turbidity on Priority Area - (a) Karimun Besar Island, (b) Demak Regency, (c) Kutai Kartanegara Regency, and (d) Surabaya City

CONCLUSION

This study concludes that while Government Regulations No. 26 of 2023 (PP 26/2023) and No. 31 of 2021 (PP 31/2021) permit commercial use of dredged sediment in Indonesia, they require technical adjustments for alignment with international standards like the OSPAR Convention, including primary data use in planning, sediment source identification, coverage of all sediment types, implementation of Best Environmental Practices (BEP) for dredging methods and reuse, worst-case impact hypotheses for licensing, and ongoing monitoring. Technically, Sentinel-2A satellite imagery analysis of water turbidity from 2021–2024 across priority sites revealed a strong, significant correlation with marine sand exports in Pulau

Karimun Besar ($r = 0.99$; $p = 0.0005$), a weaker insignificant one in Demak Regency ($r = 0.86$; $p = 0.1311$), and weak insignificant correlations in Kutai Kartanegara Regency and Surabaya City, highlighting the need for region-specific strategies. For future research, integrating ground-based validation of satellite turbidity data with real-time IoT sensors and longitudinal modeling of sedimentation dynamics could enhance predictive accuracy and inform adaptive policy reforms.

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