National TDA of Land-based Pollution and Marine Pollution Assessment — Thailand (Draft)

3.1 Key Findings / Key Pollution Concerns / Significance in National and Regional Contexts

Thailand faces significant environmental challenges from both land-based and marine pollution that pose substantial threats to economic development, public health, and ecosystem integrity. The country's rapid industrialization and urbanization over the past decades have resulted in pollution costs estimated at approximately 2 - 3% of GDP annually, representing a significant economic burden on national development (Sonthi, et.al., 2020). The assessment reveals that Thailand's pollution profile is characterized by multiple interconnected sources including industrial effluents, agricultural runoff, domestic sewage, and plastic waste.

The country faces persistent and growing pressures from land-based pollution sources, with coastal water quality most critically stressed in the Upper Gulf of Thailand. The region experiences the most severe impacts due to riverine inflows from the Chao Phraya, Tha Chin, Mae Klong, and Bang Pakong Rivers, which deliver high nutrient and organic loads, driving recurrent algal and plankton blooms and seasonal hypoxic events that cause fish kills and aquaculture losses. Table 1 outlines the key pollution concerns affecting Thailand's marine and coastal zones, highlighting their sources, impacted areas, and consequences.

Table 1: Key Pollution Concerns

Pollution Category	Key Aspects	Primary Locations	Environmental & Socioeconomic Impacts
1. Nutrient & Organic Loading	- Caused by untreated/partially treated municipal wastewater, industrial effluents, and agricultural runoff - High levels of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and nutrients (nitrogen, phosphorus) - Seasonal eutrophication and algal blooms	- Upper Gulf of Thailand (Bangkok vicinity, Chao Phraya River mouth) - Estuarine zones with high urban/agricultural discharge	- Hypoxia (low oxygen) events harming marine biodiversity - Fish kills and aquaculture losses - Reduced water quality affecting tourism and recreation

Pollution Category	Key Aspects	Primary Locations	Environmental & Socioeconomic Impacts
2. Solid Waste & Marine Litter	- ~27.2 million tonnes of municipal solid waste generated annually (2024) - Only ~10.5 million tonnes (~38%) properly treated - High leakage of plastics into waterways and coastal zones - Tourism and urban centers contribute significantly	- Coastal provinces: Chonburi, Phuket, Koh Samui, Pattaya - River mouths draining into the Gulf of Thailand	- Accumulation of marine litter on beaches and mangroves - Microplastic contamination in marine food chains - Negative impact on fisheries, tourism, and coastal aesthetics
3. Industrial & Hazardous Pollution	- Wastewater and hazardous discharges from petrochemical, manufacturing, and heavy industries - Includes heavy metals, solvents, and persistent organic pollutants - Linked to industrial expansion in the Eastern Economic Corridor (EEC)	- Rayong, Chachoengsao, Chonburi (EEC zone) - Industrial estates and export zones	- Contamination of coastal waters and sediments - Bioaccumulation in seafood affecting public health - Conflict between industrial development and fisheries/aquaculture livelihoods
4. Oil Spills & Hydrocarbon Pollution	- Risks from offshore petroleum operations, shipping lanes, and port activities - Notable incidents like the Rayong oil spill (2022) - Chronic low-level hydrocarbon pollution from vessel discharges	- Gulf of Thailand - Port areas and shipping routes - Rayong coast	- Acute damage to coral reefs, seagrass beds, and fisheries - Economic losses in tourism and seafood sectors - Long-term ecological degradation
5. High-Risk & Sensitive Areas	- Ecosystems and zones highly vulnerable to pollution stressors - Includes enclosed	- Upper Gulf of Thailand - Rayong-Chonburi coasts - Phuket, Krabi, Phi	- Loss of biodiversity and ecosystem services - Reduced resilience to climate change and

Pollution Category	Key Aspects	Primary Locations	Environmental & Socioeconomic Impacts
	bays, coral reefs, mangroves, and estuaries - Often overlap with tourism hotspots and industrial zones	Phi Islands (Andaman Sea) - Pattaya Bay, Koh Samui (Gulf) - Major river mouths and estuaries - Coral reef and seagrass ecosystems - Mangrove forests	coastal erosion - Threats to livelihoods dependent on fisheries, tourism, and coastal resources

Regional and Transboundary Significance

Thailand sits at the heart of the East Asian Seas/COBSEA region and ASEAN, making its marine pollution challenges regional in consequence:

- **Gulf of Thailand**: As a semi-enclosed sea, nutrient enrichment and pollution accumulation spread across EEZ boundaries (Thailand, Cambodia, Vietnam)
- **Marine debris transport**: Plastics and litter are transported by monsoon-driven currents into neighboring waters, contributing to regional marine debris problems
- **Andaman Sea connectivity**: Thailand shares connected ecosystems with Myanmar and Malaysia, where nutrient and waste flows affect coral reefs, fisheries, and shared biodiversity
- **Coordination needs**: Transboundary transport of plastics and nutrients requires coordinated monitoring and response through COBSEA, ASEAN frameworks, and bilateral mechanisms

Key Implications Message

Thailand's coastal and marine environments are among the country's most valuable natural assets, supporting biodiversity, livelihoods, and economic activities such as fisheries, aquaculture, and tourism. As urbanization, industrial development, and tourism continue to grow, these ecosystems face increasing pressure from nutrient pollution, solid waste leakage, and marine litter. In 2024, Thailand generated approximately 27.2 million tonnes of municipal solid waste, with only 38% properly treated—highlighting the need for improved waste management systems. Additionally, untreated wastewater and agricultural runoff contribute to seasonal eutrophication, particularly in the Upper Gulf of Thailand. Industrial zones along the Eastern Economic Corridor also present challenges in managing hazardous discharges. Addressing these issues will require strengthened national efforts alongside regional cooperation to reduce nutrient loads, enhance waste treatment infrastructure, and prevent marine litter leakage.

3.2 Current Status by indicator group

Indicators are summarized nationally with emphasis on the Gulf of Thailand and the Andaman Sea.

3.2.1 Pollution sources and Magnitude

1) Agricultural Runoff

Agricultural runoff is a significant source of pollution, primarily characterized by the presence of key parameters such as nitrogen (N), phosphorus (P), and pesticide residues. These pollutants mainly originate from fertilizer applications used in major crop production systems including rice, sugarcane, and maize. The excessive use of fertilizers and pesticides contributes to the transport of these substances into water bodies, causing serious environmental concerns.

The environmental impacts of agricultural runoff are notable, with eutrophication occurring in freshwater bodies and coastal zones, leading to excessive algal blooms and oxygen depletion. This runoff also contaminates drinking water sources, posing health risks to local communities. Furthermore, it results in the degradation of aquatic ecosystem health, affecting biodiversity and the sustainability of aquatic habitats. Despite the severity of these impacts, current monitoring of agricultural runoff in many areas remains limited, with insufficient spatial coverage and a lack of comprehensive data on seasonal variations, hindering effective management and mitigation efforts.

Fertilizer Import Data

According to data from the Department of Agriculture, Thailand imported significant quantities of straight fertilizers in 2024:

- **Nitrogen fertilizers**: 1,558,940.2 tonnes per year
- **Phosphorus fertilizers**: 571,032.0 tonnes per year

These import volumes highlight the substantial use of nitrogen and phosphorus-based fertilizers in Thai agriculture, representing a significant potential source of nutrient runoff to water bodies.

Data Gaps and Monitoring Challenges

Currently, there is no officially reported quantification of annual nitrogen and phosphorus runoff from agricultural activities. This data gap represents a critical limitation in:

- Understanding the actual environmental loading from agricultural sources

- Developing evidence-based nutrient management strategies
- Establishing effective pollution reduction targets
- Monitoring the effectiveness of best management practices

Recommendation: Establishment of systematic monitoring and reporting mechanisms for agricultural nutrient runoff is essential for comprehensive water quality management and pollution source control.

2) Marine & Coastal Water Quality

Coastal Water Quality Assessment: Key Parameters and Trends

The assessment of Thailand's coastal water quality is based on a set of core environmental indicators, including dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrient concentrations (notably nitrogen and phosphorus), and coliform bacteria levels. These parameters are essential for evaluating the ecological integrity of marine and estuarine systems and their capacity to support fisheries, aquaculture, tourism, and biodiversity.

Monitoring data has identified several primary hotspots where water quality degradation is most pronounced. These include the Upper Gulf of Thailand, particularly the Bay of Bangkok; estuarine zones adjacent to major urban centers; and river mouth discharge areas receiving high volumes of untreated or partially treated wastewater. These zones are subject to elevated pollutant loads due to dense population, industrial activity, and land-based runoff.

Recent trends indicate a decline in dissolved oxygen levels in estuarine environments, which may lead to hypoxic conditions and associated ecological stress. Additionally, elevated coliform bacteria counts have been recorded near urban coastal zones and popular tourist beaches, posing potential risks to public health and recreational water use. Seasonal fluctuations in nutrient loading—driven by agricultural runoff and hydrological cycles—further compound the vulnerability of these ecosystems.

The environmental significance of these findings is substantial. There is a demonstrable link between water quality parameters and the productivity of coastal fisheries, the sustainability of marine tourism, and the resilience of marine biodiversity. Continued monitoring and targeted interventions are essential to safeguard these critical resources and to support Thailand's commitments under regional and international environmental frameworks.

Marine Water Quality Assessment (PCD, 2024).

The Pollution Control Department (PCD) and the Department of Marine and Coastal Resources (DMCR) conducted comprehensive water quality monitoring across Thailand's coastal and marine waters in 2024, providing critical insights into the current state of marine environmental health.

Coastal Water Quality Status

Monitoring Network: 450 monitoring stations strategically positioned at varying distances from the shoreline (10, 100, and 500 meters)

Quality Classification Results:

- **Excellent**: 4% of stations (18 stations)
- **Good**: 60% of stations (270 stations)
- **Fair**: 33% of stations (149 stations)
- **Poor**: 2% of stations (9 stations)
- **Very Poor**: 1% of stations (4 stations)

Marine Water Quality Status

Monitoring Coverage: 85 monitoring stations located 3 kilometers offshore from the shoreline

Quality Classification Results:

- **Excellent**: 25% of stations (21 stations)
- **Good**: 67% of stations (57 stations)
- **Fair**: 7% of stations (6 stations)
- **Poor**: 1% of stations (1 stations)

Long-Term Trends: Marine Water Quality (2015–2024)

Analysis of the Marine Water Quality Index over the past decade reveals encouraging stability in Thailand's marine environment:

- **Overall Assessment**: Marine water quality has remained **stable** throughout the 10-year monitoring period
- **Beneficial Quality Maintenance**: The proportion of marine waters rated as beneficial (ranging from "very good" to "fair" categories) has **consistently exceeded 90%** since 2016
- **System Resilience**: Despite increasing coastal development and tourism pressures, the marine ecosystem has demonstrated remarkable resilience in maintaining acceptable water quality standards

- **2015**: Initial baseline establishment

- **2016–2024**: Sustained performance with >90% of marine waters maintaining beneficial quality ratings
- **Trend Trajectory**: Stable with no significant deterioration despite growing anthropogenic pressures

Marine Water Quality Assessment Summary

Current Status

As of 2024, Thailand's coastal waters demonstrate a predominantly positive environmental condition. Comprehensive monitoring data indicates that nearly two-thirds of coastal waters, representing 64% of assessment stations, maintain good to excellent quality standards. This measurement reflects the ongoing commitment to marine environmental stewardship across the nation's extensive coastline. The majority of Thailand's coastline continues to support healthy marine ecosystems, which are vital to both ecological integrity and the economic sectors dependent upon marine resources. However, it is noteworthy that 36% of monitoring stations report fair to poor conditions, reflecting localized pollution pressures in specific areas. These findings warrant continued attention and targeted intervention in affected regions.

Historical Performance and Effectiveness

An examination of historical performance over the past decade reveals a stabilized trajectory in coastal water quality management. This decade-long stability demonstrates that existing environmental management frameworks have been effective in maintaining or improving marine conditions. Notably, consistent beneficial quality ratings exceeding 90% across the monitoring period indicate the successful implementation and execution of pollution control measures throughout Thailand's coastal zones. Such sustained performance attests to the dedication of environmental agencies, regulatory compliance by stakeholders, and ongoing investment in marine protection initiatives.

The Marine Water Quality Index has proven to be an effective and reliable monitoring tool for assessing and tracking the nation's coastal environmental conditions. Through systematic data collection and analysis, this index provides a comprehensive foundation for evidence-based decision-making and adaptive management strategies to preserve and enhance Thailand's marine resources for future generations.

Management Implications

The combined current assessment and historical trends highlight several critical priorities for Thailand's marine water quality management. First, the long-term stability observed over the past decade indicates that existing management frameworks are effective and should be sustained as a foundation for future efforts. Second, targeted intervention is needed to focus remediation efforts on the 3% of monitoring stations with poor to very poor conditions, addressing localized pollution hotspots that continue to threaten marine ecosystems and coastal livelihoods.

Moving forward, a preventive approach is essential to maintain current protection levels while proactively addressing emerging pressures from coastal development and tourism expansion. This should be complemented by adaptive management strategies that utilize the established monitoring baseline to detect early warning signs and respond promptly to future changes in water quality conditions. Additionally, regional coordination through COBSEA and ASEAN frameworks will be crucial to share successful management practices and lessons learned with neighboring countries facing similar challenges.

In conclusion, Thailand's marine water quality demonstrates both current challenges and long-term resilience, providing a solid foundation for sustainable coastal and marine resource management. The decade-long monitoring record serves as valuable evidence that comprehensive pollution control measures, when properly implemented and maintained, can effectively protect marine ecosystems despite growing anthropogenic pressures.

3) Wastewater (Domestic & Industrial)

3.1 Domestic Wastewater Management

Current Treatment Infrastructure

As of 2024, Thailand's domestic wastewater management system comprises 214 wastewater treatment facilities distributed across the nation. These facilities collectively maintain a treatment capacity of 581.9 million cubic meters per year. Despite this substantial infrastructure investment, current treatment coverage remains limited relative to national wastewater generation demands. Approximately 2.5 million cubic meters of domestic wastewater are generated daily throughout Thailand. Of this daily volume, only 41% receives proper treatment through existing facilities, while the remaining 59% of domestic wastewater continues to lack adequate treatment. This significant coverage gap of nearly three-fifths of total domestic wastewater generation represents a substantial environmental challenge requiring urgent policy intervention and infrastructure development (PCD, 2024) *(https://dspot.pcd.go.th/)*

Key Challenges and Impacts

The current state of domestic wastewater management presents multiple interconnected challenges to Thailand's environmental and public health objectives. The infrastructure deficit is evident in the less than 40% national treatment coverage, indicating substantial investment needs to expand capacity and extend service to underserved regions. The consequence of inadequate treatment infrastructure is the direct discharge of untreated wastewater into rivers and canal systems throughout the country. This uncontrolled discharge contributes to documented water quality degradation, with a clear causal correlation between untreated wastewater discharge and deteriorating surface water quality in affected watersheds. Beyond environmental impacts, inadequate wastewater treatment poses significant risks to both environmental integrity and human health, affecting communities dependent upon affected water resources. Addressing these challenges through expanded infrastructure development, improved treatment facility efficiency, and enhanced service coverage remains critical to achieving national water quality and public health objectives.

3.2 Industrial Wastewater Management

Pollutant Profile

Thailand's industrial wastewater streams contain a complex array of contaminants that reflect the diversity of manufacturing activities across the country. The primary contaminants identified include heavy metals such as lead, mercury, cadmium, and chromium, which present significant environmental and health risks due to their persistence and bioaccumulative properties. Industrial discharges also contain organic compounds including petrochemicals, solvents, and various industrial chemicals that contribute to surface and groundwater contamination. Additionally, toxic substances specific to individual manufacturing processes present sector-dependent pollution challenges that require tailored management approaches and regulatory frameworks.

Geographic Distribution

Industrial wastewater generation is concentrated in specific regions corresponding to Thailand's major industrial zones. The Eastern Seaboard represents a significant concentration of petrochemical and heavy industry operations, making it a critical area for wastewater management and pollution control oversight. The Bangkok Metropolitan Region encompasses diverse industrial activities including manufacturing, food processing, and textile production, each presenting distinct wastewater management requirements. Beyond these major centers, regional industrial estates distributed throughout the country contribute to national wastewater volumes and require ongoing monitoring and regulatory attention.

Regulatory Compliance Status

Compliance with industrial wastewater regulations demonstrates significant variability across Thailand's industrial landscape. Sector-specific performance data indicates that compliance rates differ substantially depending on industry type and operational characteristics. Large-scale industrial operations generally maintain higher compliance rates compared to small and medium enterprises, reflecting differences in technical capacity, financial resources, and regulatory engagement. A notable challenge in achieving comprehensive compliance stems from gaps in monitoring and enforcement capacity, particularly in remote industrial areas where regulatory oversight is limited. These enforcement challenges compromise the effectiveness of existing regulatory frameworks and necessitate enhanced resource allocation to monitoring and compliance verification activities.

Critical Issues and Management Gaps

The management of industrial and domestic wastewater reveals interconnected challenges requiring coordinated policy responses and strategic investments.

Domestic Wastewater Priorities: Infrastructure investment remains urgently needed to address the existing 59% coverage gap in domestic wastewater treatment. A significant rural versus urban disparity characterizes current treatment access, with urban centers generally benefiting from more developed infrastructure while rural communities face limited-service provision. Aging infrastructure throughout the nation requires systematic upgrading and regular maintenance to ensure operational effectiveness and treatment efficiency.

Industrial Wastewater Priorities: Enforcement consistency must be strengthened through enhanced regulatory oversight and more rigorous compliance monitoring mechanisms. The adoption of cleaner production technologies should be actively encouraged through incentive programs and technical support to reduce pollutant generation at the source. Small and medium enterprises require enhanced technical and financial assistance programs to facilitate compliance with environmental regulations and to enable adoption of improved wastewater treatment technologies. These coordinated interventions are essential to achieving comprehensive wastewater management across both domestic and industrial sectors.

Strategic Priorities

Short-term actions are required to address the current wastewater management challenges. These include accelerating the construction of domestic wastewater treatment facilities to close the existing coverage gap, strengthening industrial discharge monitoring and enforcement mechanisms to ensure regulatory compliance, and implementing stricter penalties for non-compliance to create effective deterrents against pollution violations.

In the long term, Thailand must pursue ambitious yet achievable goals to transform its wastewater management system. The country should aim to achieve 80% domestic wastewater treatment coverage by 2030, establish comprehensive industrial wastewater tracking systems that provide real-time monitoring and data transparency, and integrate wastewater management with broader water resource planning to ensure holistic and sustainable approaches to water security.

Regional coordination is equally essential to addressing shared water quality challenges. Thailand should align its industrial wastewater standards with international best practices to maintain competitiveness while protecting the environment, actively share treatment technologies and management experiences with neighboring countries to build regional capacity, and coordinate transboundary pollution prevention strategies through existing mechanisms such as COBSEA and ASEAN to protect shared marine and coastal resources.

4) Municipal Solid Waste Situation in Thailand (PCD, 2024)

Waste Generation Overview

In 2024, Thailand generated approximately 27.20 million tonnes of municipal solid waste, representing a daily generation rate of approximately 74,529 tonnes. This volume reflects a 0.9% increase compared to 2023, when the country generated 26.95 million tonnes of municipal solid waste. While this year-on-year growth rate is modest, it underscores the ongoing challenge of managing expanding waste volumes in alignment with sustainable development objectives. The consistency in waste generation levels demonstrates the importance of maintaining robust waste management infrastructure and operational capacity to effectively process the nation's municipal solid waste streams.

Waste Management Flow Analysis

Thailand's waste management system encompasses multiple pathways through which municipal solid waste is processed from generation through final disposition. Understanding this complex management flow is essential to identifying system inefficiencies and opportunities for optimization.

Initial Waste Management at Source

A portion of generated waste undergoes treatment and processing at the point of origin before entering formal waste management systems. Source-level management accounts for 1.54 million tonnes, representing 6% of total waste generation. This waste is managed through household-level composting, backyard burning, and other source-level treatment methods. These decentralized practices reduce the volume of waste requiring formal collection and processing, thereby decreasing overall system burdens while promoting individual household engagement in waste reduction activities.

Pre-Collection Utilization and Recovery

Substantial quantities of waste are separated and recovered for beneficial use directly from generation sources before entering the formal waste collection system. Utilized-before-collection waste volumes total 6.02 million tonnes, representing 22% of total waste generation. This pre-collection recovery encompasses recycling activities by informal waste pickers operating throughout communities, material recovery by households engaging in source separation practices, and direct reuse practices where materials are repurposed without intermediate processing. This significant pre-collection recovery pathway reflects active circular economy engagement across Thai society and demonstrates the substantial role of informal waste recovery activities in the national waste management system.

Formal Collection Operations

The local government collection system represents the primary mechanism through which waste enters formal waste management pathways. Waste collected by local authorities totals 19.64 million tonnes, representing 72% of total waste generation. This high collection rate reflects substantial municipal infrastructure investment and operational capacity dedicated to ensuring comprehensive waste collection services across urban and rural areas. The collected waste is subsequently transported to formal disposal facilities or transfer stations for processing and final disposition.

Post-Collection Recovery and Processing

Following collection and transport to formal facilities, a portion of waste undergoes separation and recovery processes for beneficial reuse and recycling. Post-collection utilization accounts for 4.49 million tonnes of collected waste, representing 17% of total generated waste. These recovery operations occur at transfer stations, material recovery facilities, and disposal sites, where waste is processed to extract valuable materials for secondary use. Post-collection recovery mechanisms represent important opportunities to maximize resource efficiency and minimize disposal volumes within formal waste management systems.

Final Disposal Requirements

After accounting for source management, pre-collection recovery, and post-collection recovery, the remaining waste requires final disposition through waste management facilities. This remaining waste volume totals 15.15 million tonnes, representing 55% of originally generated waste. The final disposal pathway represents the terminal stage of waste management processing, requiring infrastructure and operational capacity to safely manage waste that cannot be recovered or treated through other mechanisms.

Disposal Quality Assessment

The quality of disposal operations demonstrates substantial variation in environmental management standards. Proper disposal management accounts for 10.42 million tonnes of waste, representing 38% of total generated waste. This waste receives appropriate disposal through sanitary landfills, waste-to-energy facilities, and other environmentally sound methods that minimize environmental and public health risks.

Improper disposal remains a critical concern, with 4.73 million tonnes of waste—representing 17% of total generated waste—being disposed of through inadequate methods including open dumping, uncontrolled burning, and disposal in unsuitable locations. This improper disposal volume represents both an environmental liability and a significant gap in waste management infrastructure and operational standards that requires urgent attention and remediation.

Table 2: Key Performance Indicators of Municipal Solid Waste Situation

Management Category	Volume (Million Tonnes)	Percentage of Total
Total Generated	27.20	100%
Managed at Source	1.54	6%
Utilized Before Collection	6.02	22%
Collected by Authorities	19.64	72%
Utilized After Collection	4.49	17%
Final Disposal	15.15	55%
- Proper Management	10.42	38%
- Improper Management	4.73	17%

Critical Assessment of Waste Management System

Positive Aspects

Thailand's waste management system demonstrates several commendable operational achievements. The collection rate of 72% reflects strong municipal service delivery infrastructure across urban and peri-urban areas, indicating substantial investment in and commitment to waste collection services. This high collection coverage establishes a robust foundation for downstream waste processing and management activities. Furthermore, the combined pre- and post-collection recovery rate of 39% demonstrates active engagement with circular economy practices. This recovery performance indicates that a substantial portion of collected waste materials are being redirected toward reuse and recycling pathways, reducing the volume of waste requiring final disposal. Additionally, proper disposal management covers 38% of total waste generation, representing significant infrastructure capacity dedicated to environmentally sound waste treatment and disposal operations. These positive developments reflect ongoing efforts to transition toward more sustainable waste management practices.

Areas of Concern

Despite these positive achievements, significant challenges remain within Thailand's waste management framework. Improper disposal represents a critical concern, with 17% of total generated waste—equivalent to 4.73 million tonnes annually—lacking proper environmental management. This substantial volume of improperly managed waste represents both an environmental liability and a missed opportunity for resource recovery. A notable gap exists between collected waste volumes and the quantity of waste receiving proper disposal, indicating structural infrastructure and management deficiencies within the waste management system. This collection-to-disposal gap reflects incomplete integration of waste management operations and highlights areas where collection capacity exceeds treatment and disposal infrastructure. Environmental risks associated with improper disposal are particularly acute, with documented correlations between inadequately managed waste and leakage of contaminants into water bodies. Improperly disposed waste represents a significant source of marine litter generation and terrestrial environmental contamination.

Management Implications and Strategic Priorities

Addressing the identified deficiencies requires urgent and coordinated action across multiple dimensions of waste management infrastructure and governance. Infrastructure investment constitutes the most pressing priority, with an urgent need to expand proper disposal capacity to manage the 4.73 million tonnes of annually improperly managed waste. Current infrastructure gaps must be systematically addressed through strategic capital investment in treatment and disposal facilities. Technology upgrading remains essential to improving waste management system efficiency. Enhanced sorting, recycling, and treatment facilities must be deployed to maximize resource recovery and minimize final disposal volumes. Regional coordination across local government boundaries requires strengthening to ensure integrated waste management planning and consistent environmental standards. The direct correlation between improper waste management and marine litter generation necessitates immediate and focused attention to prevent environmental contamination of Thailand's marine resources. Comprehensive waste management reform addressing these implications is essential to achieving sustainable resource management and environmental protection objectives.

5) Hazardous Waste

- Industrial hazardous waste: 1.63 million tons of hazardous industrial waste out of 16.8 million tons total industrial waste generated annually (2024 data), with processing capacity of 37.6 million tonnes per year available (PCD, 2024).
- Medical and infectious waste: Thailand maintains 188,321 tons per year disposal capacity through 19 agencies (18 incineration plants with 186,479 tons/year capacity and 1 steam sterilizer with 1,752 tons/year capacity); normal generation rate averages 0.41 kg per hospital bed per day (Ministry of Public Health, 2022).
- Electronic waste (e-waste): 439,000 tonnes generated annually (2024), ranking Thailand third in ASEAN after Indonesia (1.89 million tonnes) and Philippines (537,000 tonnes); domestic generation estimated at 418,113 tons per year (2020 data) with only 22% properly treated (Global E-Waste Monitor, 2025; Ministry of Industry, Thailand, 2025).
- Household hazardous waste: 685,999 tons, representing a 0.8% increase from 2023 (680,386 tons), composition of WEEE (waste from electrical and electric equipment) 445,899 tons (65%), and other hazardous household waste (light bulbs, batteries, chemical containers, spray cans) 240,100 tons (35%) (PCD, 2024; Jawjit, et.al, 2024).
- Agricultural hazardous waste: Over 516,000 tons of pesticides used by February 2021, generating significant volumes of contaminated containers and expired chemicals requiring specialized management (Thailand Agricultural Sector Report, 2025).

6) Aquaculture Pollution

- Coastal shrimp farming: Government limit set at 500,000 rai (80,000 hectares) with annual production capped at 200,000 tonnes; currently 26,000+ marine shrimp farms operating (2022), with actual production of 270,000 tonnes in 2024 (90% from coastal culture) (Department of Fisheries, 2025).
- Organic loading from feed waste: Feed conversion ratios typically 1.5-2.5:1 in intensive systems; only 20-30% of nitrogen and 10-15% of phosphorus in feeds are retained in shrimp biomass, with remainder discharged as waste; phosphorus losses from aquaculture estimated at 10,188 tonnes P/year (89% of total fisheries sector losses) (Prathumchai et al., 2016).
- Chemical use patterns: Antibiotic consumption estimated at 500-600 metric tons in shrimp farming (1994 baseline); antibiotics detected in aquaculture wastewater at concentrations ranging 3.36-85,000 ng/L; commonly used chemicals include oxytetracycline, chloramphenicol, furazolidone, and various disinfectants (Sharma et al., 2021; Dierberg, 1996).
- Pond discharge impacts: Water quality degradation through loadings of suspended solids, oxygen-consuming organic matter, and nutrients; cumulative impacts from water exchange during grow-out, pond drainage at harvest, and illegal sediment disposal; salinization of freshwater resources from brackish water aquaculture; antimicrobial resistance genes detected in coastal aquaculture regions.

7) Industrial Waste

Composition and Quantities

Industrial waste globally amounts to about 9.2 billion tonnes yearly, representing nearly half of worldwide waste, but only about 2% is recycled (Business Waste, 2025). Industrial waste composition varies substantially by sector, but key components include sludge, solvents, metals, plastics, paper, cardboard, and rubber.

Industrial Waste Management in Thailand

Thailand requires factories to follow the Factory Act and Ministry of Industry notifications regulating industrial waste disposal, including registration and separate handling of hazardous and non-hazardous waste. Notably, many factories are located in industrial estates where further regulatory frameworks apply, such as detailed reporting and waste separation standards (Siam City Cement, 2021; Waste Management Thailand, 2025).

Hotspots and Regional Data

Key industrial waste hotspots in Thailand include the provinces of Rayong, Chonburi, and Samut Prakan. For example, the AMATA industrial estates in Rayong and Chonburi generated approximately 6,781 tons of sludge in 2024, fully reused within the estates, showing progress in sustainable waste utilization (AMATA, 2025). Industrial wastes here mainly consist of sludge, metals, paint, plastic, rubber, and batteries.

Monitoring and Data Gaps

Monitoring of industrial waste, especially long-term accumulation, remains incomplete. Advanced technologies like IoT sensors, AI, and big data are increasingly used for real-time waste production monitoring, improving accuracy and efficiency, but comprehensive national data is still lacking (SBN Software, 2025).

Table 3: Summary Industrial Waste Aspect

Aspect	Details	Numbers	References
Global industrial waste generation	~9.2 billion tonnes yearly	9.2 billion tonnes	Business Waste (2025)
Thailand waste management laws	Factory Act, Ministry notifications	Mandatory registration & regulation	Siam City Cement (2021), Waste Management Thailand (2025)
Hotspots in Thailand	Rayong, Chonburi, Samut Prakan	6,781 tons sludge in AMATA	AMATA (2025),
Monitoring status	Incomplete long-term data, increasing use of IoT & AI	Emerging real-time monitoring tech	SBN Software (2025)

Industrial Waste Recycle

Recent statistics indicate that the industrial waste recycling rate in Thailand is projected to reach around 51% by 2024, reflecting significant growth driven by government policies promoting waste reuse and circular economy models. However, challenges remain due to insufficient waste separation knowledge among the public and suboptimal waste management systems.

Globally, only about 6.9% of the total materials used annually come from recycled sources, with industrial sectors producing much more waste than households and pushing for innovations in smart waste management systems to improve recycling rates. In Thailand, the recycling and utilization of municipal plastic waste is forecasted to reach above 90% by 2030 under a national roadmap scenario, although the 2025 target may be slightly lower due to plastic waste being prioritized for energy recovery uses.

Additionally, some private sector data show recycling of industrial waste could be quite high, with reports indicating about 88.37% of total industrial waste generated managed through recycling and other diversion methods in some cases.

8) Oil Pollution Sources and Incidents

Oil pollution in Thailand primarily stems from shipping activities, offshore drilling, and port operations, with at least 240 recorded oil spill incidents since 1974 concentrated in the Gulf of Thailand and the Andaman Sea. Significant spills include the 2016 incident near Koh Samet, where about 50,000 liters of oil contaminated Ao Prao beach, severely harming tourism and marine ecosystems. More recent major spills occurred in January 2022 near Map Ta Phut port in Rayong province, releasing approximately 47,000 liters of crude oil and impacting fisheries and beaches, and in September 2023, when about 60,000 liters spilled from a tanker in Si Racha, Chonburi. Additionally, since 2014, the Department of Marine and Coastal Resources has detected 44 unidentified spills mostly along the eastern Gulf coast.

Response Capacity:

Thailand has established a National Oil Spill Contingency Plan, B.E. 2545 (2002) with a tiered response system based on spill volume: (Ministry of Transport, 2002)

Tier 1: spills less than 20 tonnes handled locally.

Tier 2: spills 20-1000 tonnes involve national efforts and multiple agencies.

Tier 3: spills over 1000 tonnes require international assistance.

Impact Zones

The Gulf of Thailand and the Andaman Sea are the most affected areas, with ecological risks concentrated in eastern coastal provinces during peak shipping seasons. Mangroves and coral reefs in these zones are particularly vulnerable.

Table 4: Summary oil spill Pollution in Thailand

Incidents	Details	Numbers
Total recorded oil spills since 1974	Multiple sources including shipping, offshore drilling	240+ incidents
2016 Koh Samet spill	Oil spilled on Ao Prao beach	~50,000 liters oil

Incidents	Details	Numbers
2022 Map Ta Phut spill	Crude oil leak affecting fisheries	~47,000 liters
2023 Si Racha spill	Tanker oil leak	~60,000 liters
Spill response tiers	Tiered national contingency system	Tier 1:<20t, Tier 2: 20-1000t, Tier 3:>1000t
Most impacted zones	Gulf of Thailand, Andaman Sea	Eastern Gulf coast hotspots

3.2.2 Pollution Hotspots and Sensitive Areas

Hotspots:

1. Upper Gulf of Thailand: The convergence of the Chao Phraya, Tha Chin, and Mae Klong rivers carries pollution from Bangkok and the central plains, creating a severe pollution load. The areas around Map Ta Phut Industrial Estate (Rayong) are also critical.

2. Tourist Destination Beaches and Bays: Patong Beach (Phuket), Maya Bay (Phi Phi Islands), and Chaweng Beach (Koh Samui) suffer from wastewater and solid waste overload, especially during high season.

3. River Mouths and Estuaries: The mouths of major rivers act as conduits for pollution, affecting estuarine ecosystems.

Sensitive Areas:

1. Coral Reefs: e.g., in the Andaman Sea (Similan Islands, Surin Islands) and the Gulf (Koh Tao, Chumphon), are highly sensitive to sedimentation, nutrient loading, and rising temperatures.

2. Mangrove Forests: Critical for carbon sequestration and coastal protection, but are threatened by aquaculture pond expansion and pollution.

3. Seagrass Beds: Important foraging grounds for dugongs and sea turtles, vulnerable to sedimentation and water quality degradation.

3.3 Discussion and conclusions

3.3.1Priority Transboundary Pollution Issues

Transboundary marine water quality pollution in Thailand and the ASEAN region involves significant nutrient pollution, alongside plastic pollution and other contaminants. Nutrient pollution primarily originates from agricultural runoff, untreated wastewater, and industrial discharges. Excessive nitrogen and phosphorus compounds transported via rivers and coastal waters lead to eutrophication, resulting in harmful algal blooms, oxygen depletion, and degradation of marine ecosystems. This common problem affects multiple ASEAN countries sharing marine waters, making it inherently transboundary.

According to the ASEAN Marine Water Quality Management report by the Pollution Control Department (PCD), coastal and estuarine waters in the region have experienced increased nutrient loads due to intensified land-based activities including agriculture, urbanization, and aquaculture. The accumulation of nutrients and pollutants is exacerbated by population growth and industrial activities, especially near river mouths and urban centers. The transboundary movement of pollutants, including nutrient-rich effluents carried by ocean currents, requires multinational governance and management approaches. (PCD, 2024)

ASEAN member states have prioritized nutrient pollution control within their regional action plans by harmonizing water quality monitoring standards, sharing data, and implementing best practices on waste treatment and agricultural runoff reduction. International programs like PEMSEA provide technical and governance frameworks supporting these initiatives. Efforts emphasize integrated coastal zone management, cross-country collaboration, and ecosystem-based approaches to restore and protect marine water quality.

China-ASEAN sub-regional cooperation on coral reefs and marine ecosystem conservation integrates nutrient pollution management, focusing also on blue carbon habitats that mitigate climate change while sustaining marine biodiversity. Bilateral arrangements, such as between China and Thailand, highlight the role of targeted partnerships to address nutrient and broader marine pollution issues at manageable scales, supporting eventual regional expansion.

These insights underscore how nutrient pollution as a transboundary marine water quality threat demands multilateral coordination, science-based policies, and enforced regulations across ASEAN and neighboring countries.

Marine Plastic Pollution:

Thailand is the world's tenth largest marine plastic polluter, with an average of 1.03 million tonnes of mismanaged waste annually, nearly half (0.41 million tonnes) flowing into the sea (TDRI, 2024). Marine debris, especially plastic pollution, is a significant transboundary environmental issue for Thailand, closely linked to regional dynamics in Southeast Asia. In 2023, Thailand's upper Gulf of Thailand received about 882 tonnes of marine debris, a notable reduction from 1,636 tonnes in 2022. Single-use plastics such as food bags, handle bags, and thin plastic films dominated, reflecting common consumption patterns and improper waste management behaviors (PCD, 2024). Plastic debris types include 12% plastic debris, 10% Styrofoam, 8% food wrappers, 8% plastic bags, among others. (TDRI, 2024).

Thailand is ranked as the sixth largest contributor to marine plastic debris globally, driven by population growth, consumer lifestyle changes, increased plastic production, economic expansion, and online shopping trends. The COVID-19 pandemic further increased plastic waste by approximately 15% nationwide, with Bangkok alone seeing a 62% increase, exacerbating marine pollution (World Bank, 2023).

Marine plastic debris is transported by ocean currents, crossing national boundaries and impacting marine ecosystems and coastal economies throughout the ASEAN region. The Thai government participates actively in regional cooperation frameworks and ASEAN initiatives aimed at reducing marine plastic pollution through a circular economy approach and extended producer responsibility (EPR) systems (World Bank, 2023)

Recent data on plastic types washing ashore in Thai coastal regions shows that single-use plastics dominate the marine debris. According to a 2024 report from the Pollution Control Department of Thailand, common types of plastic debris found along the coast include food bags, handle bags, thin plastic films, as well as fragments of polyethylene, polypropylene, polystyrene, PVC, and PET. These plastics originate mostly from consumer products and packaging materials reflecting widespread use and improper disposal behaviors.

Marine plastic pollution is a key issue for ASEAN, with regional cooperation efforts ongoing (World Economic Forum, 2025). ASEAN has recognized marine plastic pollution as a regional transboundary challenge and initiated important collaborative frameworks to combat this issue. The “Bangkok Declaration on Combating Marine Debris in the ASEAN Region” (2019) and the ASEAN Framework of Action on Marine Debris exemplify regional commitment to strengthening cooperation for marine environment protection. These frameworks promote integrated policies, harmonized regulations, data sharing, capacity building, and joint enforcement to reduce plastic leakage and other pollutants entering marine waters (ASEAN Secretariat, 2024).

ASEAN regional cooperation efforts to combat marine plastic pollution have been rapidly advancing, with a focus on collective action and sustainable plastics management. The ASEAN Conference on Combatting Plastic Pollution (ACCPP), established in 2023, serves as a key platform for regional stakeholders to exchange knowledge, coordinate strategies, and align actions. The 2025 ACCPP held in Kuala Lumpur under Malaysia’s ASEAN Chairmanship continued this momentum with the theme "All Hands on Deck: Uniting Forces for a Sustainable Plastics Future," emphasizing multi-stakeholder involvement including governments, businesses, civil society, and academia.

ASEAN's regional cooperation on marine plastic pollution includes several prominent initiatives, among which the Southeast Asia Regional Program on Combating Marine Plastics (SEA-MaP) stands out as a vital project funded by the World Bank. SEA-MaP supports ASEAN Member States in implementing the ASEAN Regional Action Plan for Combating Marine Debris (RAP), aiming to reduce plastics consumption, increase recycling, and minimize plastic leakages into marine and coastal environments. The project focuses on strengthening policies, harmonizing regulations, enhancing monitoring and data collection, and building capacity among decision-makers and stakeholders to achieve plastics circularity and sustainable waste management throughout the region.

SEA-MaP, launched in 2022 and running until 2027, serves as a catalyst for regional collaboration by developing guidelines and promoting multi-sectoral partnerships within ASEAN's existing institutional frameworks. It supports capacity-building programs to enable governments, the private sector, and communities to implement more effective solutions to marine plastic pollution. In conclusion, the SEA-MaP project is a cornerstone initiative within ASEAN's regional cooperation framework, enhancing policies, capacities, and partnerships to mitigate marine plastic pollution effectively.

3.3.2Interactions [impacts on Environment and Society]

Environmental Impacts:

Thailand is confronted with extensive environmental challenges resulting from various forms of pollution that adversely affect marine and freshwater ecosystems, air quality, and soil integrity. Notably, over one million tonnes of plastic waste are introduced into Thai marine environments annually, precipitating significant degradation of marine biodiversity and jeopardizing fisheries upon which local communities depend for food and livelihoods (World Bank, 2023). Concurrently, approximately 30% of the nation's coral reefs experience bleaching and structural damage due to a combination of coastal pollution and rising ocean temperatures driven by climate change (ASEAN Secretariat, 2024). The freshwater ecosystem is similarly affected, as evidenced by water quality assessments indicating that 43% of monitored water bodies hold only fair ecological status, while 18% are classified as poor, largely owing to nutrient enrichment from agricultural runoff and urban effluents (PCD, 2024). Furthermore, localized soil contamination resulting from improper disposal of industrial waste presents additional environmental hazards (Thammasat University, 2025).

These multifaceted environmental detriments manifest considerable socio-economic repercussions, including diminished tourism revenue, elevated healthcare expenditures, and disproportionate impacts on vulnerable populations such as coastal communities and outdoor laborers. Addressing these interlinked challenges necessitates the implementation of holistic and coordinated environmental management strategies, reinforced regulatory frameworks, regionally integrated cooperation, and enhanced public engagement to safeguard Thailand's ecological integrity and promote sustainable development.

Social Impacts:

The social impacts of environmental pollution in Thailand are profound and multifaceted. According to a 2025 nationwide survey conducted by Marketbuzzz in collaboration with Thammasat University's School of Global Studies, approximately 65% of Thai citizens perceive environmental issues as significantly impacting their quality of life, with 48% anticipating further deterioration over the next five years. Despite this heightened awareness, actual pro-environmental behaviors remain limited, with only 23% refusing plastic bags at retail outlets, highlighting a notable gap between concern and action (Thammasat University, 2025).

Economic repercussions are substantial, as degradation of coastal and marine environments contributes to losses estimated in the billions of US dollars annually within the tourism sector, a critical component of Thailand's economy (World Bank, 2023). Additionally, the fisheries industry experiences adverse effects due to marine pollution; research indicates microplastic contamination in 87-93% of commercially harvested bivalves, raising acute food safety concerns and risking public health. Vulnerable groups, including coastal populations and outdoor laborers, disproportionately bear health risks associated with pollution exposure, underscoring socio-environmental inequities (Pollution Control Department, 2024). Emerging challenges to food security arise from pollutant bioaccumulation in both agricultural products and marine resources, exacerbating risks to community nutrition and wellbeing (PEMSEA, 2024).

This synthesis illustrates the critical intersection of environmental degradation with social and economic dimensions in Thailand, emphasizing the need for integrated policy responses and public engagement to mitigate these impacts.

Economic Impacts:

Economic impacts related to marine water pollution in Thailand are considerable and multifaceted. Direct healthcare costs from illnesses associated with polluted marine environments, such as exposure to contaminated seafood and waterborne diseases, contribute significantly to public health expenditures, though exact nationwide figures vary by pollutant and locality. The Department of Marine and Coastal Resources (DMCR) estimates that degradation of marine habitats, including coral reefs and fisheries, indirectly drives up healthcare demands due to ecosystem service losses that affect food security (DMCR, 2024).

Tourism revenue losses are substantial, with the ASEAN Secretariat (2024) estimating declines in the billions of USD annually due to polluted beaches and marine habitats, which undermine Thailand's attractiveness as a tourist destination, crucial for local economies. The World Bank (2023) underscores that coastal erosion and marine pollution combined have led to an estimated land value loss exceeding $1.3 billion, further impacting tourism infrastructure and real estate.

Water treatment and environmental remediation efforts are increasingly costly due to nutrient runoff and marine plastic pollution. The Pollution Control Department (PCD) reports that expenditures on water treatment facilities and cleanup initiatives have escalated significantly in recent years, straining both governmental budgets and private sector investments (PCD, 2024).

Long-term sustainability threats remain acute, as continued environmental degradation jeopardizes economic stability. The World Bank (2023) highlights that without stronger pollution control and investment in sustainable marine resource management, economic growth prospects in coastal provinces and related industries may decline sharply.

These data emphasize the importance of integrated policies and financing mechanisms to mitigate marine pollution impacts and promote sustainable economic development in Thailand.

3.3.3Risk Assessment

Thailand generates over 3.2 million tonnes of plastic waste annually, with nearly 46% of this amount being mismanaged, equating to 1.48 million tonnes of improperly handled plastic waste per year (Earth Action, 2024). This mismanagement rate is nearly double the global average, leading to significant environmental pollution risks and associated economic costs. The plastics industry contributed approximately 7.7% of Thailand's GDP in 2021, with expectations to grow annually by over 5% until 2029, underscoring its economic importance despite the environmental challenges (Earth Action, 2024).

To curb pollution, the Thai government has instituted stringent policies, including a phased ban on plastic waste imports, fully effective by 2025. This aims to prevent Thailand from becoming a destination for foreign plastic waste, thereby reducing environmental hazards and protecting public health (National News Bureau, 2023). Despite campaigns to boost recycling, only 17.6% of key plastics were recycled in 2018, reflecting challenges in waste management infrastructure and behavioral change (Earth Action, 2024).

Economic impacts linked to this pollution include increased healthcare costs from disease linked to environmental contamination, losses in tourism revenue due to degraded coastal waters, and elevated expenses for water treatment and environmental remediation borne by governments and businesses alike (PCD, 2024; ASEAN

Secretariat, 2024). Long-term sustainability is under threat as environmental degradation poses risks to economic stability and growth (World Bank, 2023).

These statistics emphasize the urgency of strengthening waste management, implementing policy measures, and fostering behavioral change to mitigate plastic pollution's economic and environmental impacts in Thailand.

3.3.4 Interactions [Current Management and Institutions]

Thailand has established a robust institutional and policy framework for managing marine water quality pollution, involving multiple national agencies and regional cooperation mechanisms. Key national institutions include the Pollution Control Department (PCD) under the Ministry of Natural Resources and Environment, responsible for monitoring marine water quality through the Marine Water Quality Index (MWQI) system, and the Department of Marine and Coastal Resources (DMCR), which conducts coastal marine ecosystem assessments and plastic debris removal campaigns. The Industrial Estate Authority of Thailand, Metropolitan Waterworks Authority, and Royal Department of Irrigation also contribute to pollution management through regulation of industrial waste, water supply quality, and watershed management, respectively (PCD, 2024).

Thailand has regulations related to the land-based pollution including waste water effluent standards, inland and seawater quality standards under and other related regulations under the Enhancement and Conservation of National Environmental Quality Act B.E. 2535. Thailand operates under comprehensive frameworks like the National Environment Quality Management Plan (2018 – 2027) and the Bio-Circular Green Economy (BCG) strategy, which integrates sustainability principles across sectors, including renewable energy targets set out in the National Energy Plan. The Sustainable Packaging Materials Management Bill, established in 2025, aims to reduce plastic waste and promote recycling by mandating sustainable packaging design and extended producer responsibility.

On the regional front, Thailand actively engages in ASEAN-led initiatives such as the ASEAN Regional Action Plan for Combating Marine Debris (2021-2025), which sets measurable targets including a 50% reduction in marine plastic debris by 2027. The ASEAN Agreement on Transboundary Haze Pollution addresses cross-border air and water pollutants, while the Southeast Asia Program to Combat Marine Plastic Pollution (SEA-MaP) enhances coordinated policy implementation and capacity building. ASEAN+3 environmental cooperation further facilitates joint management and data sharing between Thailand, its ASEAN neighbors, China, Japan, and South Korea (ASEAN Secretariat, 2024; PEMSEA, 2024).

Thailand's integrated approach has produced tangible outcomes; for example, the PCD reported removal of over 220 tonnes of marine debris from coastal ecosystems in 2023, and average MWQI values have improved in many coastal zones. Nonetheless, challenges remain in enforcement and expanding infrastructure to match economic growth and urbanization (PCD, 2024; World Bank, 2023).

This institutional and policy ecosystem positions Thailand as a proactive actor in marine pollution management while highlighting the ongoing need for strengthened enforcement, infrastructure investment, and regional collaboration.

3.3.5Gaps and Priority Challenges

Thailand faces significant gaps and priority challenges in managing environmental pollution, spanning institutional, technical, financial, and knowledge domains.

Institutionally, coordination between national and local agencies remains limited, with sectoral ministries operating in silos, hindering effective integrated pollution. Enforcement capacity is weak; for instance, only 60% of reported environmental violations are penalized due to resource constraints (ONEP, 2023). Monitoring systems lack comprehensive coverage, especially in rural and coastal areas.

Technically, wastewater treatment infrastructure is insufficient, with rural areas disproportionately underserved. Hazardous waste management capacity is constrained, with existing treatment centers handling, and planned expansion facing delays due to local opposition. Solid waste management challenges prevail in smaller municipalities, and incineration or sanitary landfill facilities are limited. Marine pollution monitoring capabilities are also insufficient to capture emerging pollutants comprehensively.

Financial gaps include limited funding for environmental infrastructure, with annual budget allocations insufficient to meet growing demands. Economic incentives and cost recovery mechanisms for pollution prevention lag, deterring private sector investment, though recent sustainability-linked bonds have raised over 30 billion baht for green infrastructure initiatives (ADB, 2024).

In knowledge and capacity, public awareness is growing but behavioral change remains slow; only 23% of surveyed Thai citizens refuse plastic bags despite high environmental concern (Thammasat University, 2025). Technical expertise in advanced pollution management technologies is limited, affecting adoption of innovative solutions. Furthermore, research capacity, particularly in pollution assessment and monitoring, needs strengthening to support evidence-based policymaking.

Addressing these intertwined challenges will require enhanced inter-agency collaboration, expanded infrastructure investment, improved enforcement, incentivization of green practices, and capacity-building programs, aligned with national policies and regional cooperation frameworks.

This synthesis highlights the critical priority areas for Thailand to bolster environmental governance and infrastructure to effectively combat pollution challenges.

3.3.6 Recommended Priority Actions, Emphasizing Regional Cooperation

Immediate Actions (1-2 years)

1. Strengthen Regional Monitoring Systems
   - Establish harmonized marine pollution monitoring protocols with ASEAN partners
   - Implement real-time data sharing mechanisms for transboundary pollution tracking
   - Develop joint early warning systems for pollution incidents
2. Enhance Waste Management Infrastructure
   - Accelerate implementation of Extended Producer Responsibility schemes
   - Improve waste collection systems in coastal and rural areas
   - Establish regional plastic waste trading mechanisms
3. Improve Regulatory Enforcement
   - Strengthen inter-agency coordination mechanisms
   - Enhance monitoring and compliance systems
   - Implement graduated penalty systems for pollution violations

Medium-term Actions (3-5 years)

1. Regional Policy Harmonization
   - Align national pollution standards with regional benchmarks
   - Develop common approaches to plastic waste management
   - Establish regional certification systems for sustainable products
2. Technology Transfer and Capacity Building
   - Facilitate knowledge sharing on pollution prevention technologies
   - Establish regional training programs for environmental management
   - Promote joint research and development initiatives
3. Economic Instruments
   - Implement regional carbon pricing mechanisms
   - Develop green bond markets for environmental infrastructure
   - Establish pollution trading systems where appropriate

Long-term Actions (5-10 years)

1. Ecosystem-based Management:
   - Implement integrated coastal zone management approaches
   - Establish transboundary marine protected area networks
   - Develop regional ecosystem restoration programs
2. Innovation and Technology
   - Promote development of biodegradable alternatives to conventional plastics
   - Advance circular economy principles in regional supply chains
   - Develop next-generation pollution monitoring technologies

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